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## PHYSICAL SCIENCE AND ITS CONNECTIONS.

PROGRESS consists in the reconciling of apparent contradictions. Unity and differentiation, heredity and variability, are apparently opposed. Yet a mammal is more truly a unit than an organism that suffers little from being cut in two because each part can do the work of all. A civilised state with interdependent specialised interests suffers from the incapacity or rapacity of its classes more than a company of Fuegans, each of whom can supply all his own wants. Science is progressing in this way. Biology cannot advance without chemistry, geology leans on physics, and this interdependence is due to specialisation, to differentiation. In organisms and states intercommunication is essential to preserve this corporate life. Without nerves and blood-vessels an amœba may possibly get on fairly well. Fuegans do not require railways or telephones. Science requires its blood-vessels and nerves, its railways and telephones. Each member requires what is elaborated by others to be collected and sorted and distributed for its use. It is most important that the work done in physical science in innumerable laboratories should be collected, digested, distributed for the information of the biologist, the chemist, the geologist. The study of the properties of each kind of matter as related to energy and the ether has bearings on every department of science and on every kind of

practice; on agriculture and medicine the practical applications of biology, and on manufactures and engineering the practical application of physics and chemistry. Whether we are using the ether to transmit energy to ploughs, or measuring the irregular energy of the tissues of a patient by a thermometer, or taking nails out of wheat with magnets, or determining the physical changes produced in materials by small amounts of impurities, we require to understand physical science, and any day some advance in it may be of service in practice. The connections, the railways, the nerves, in this department, are fairly well supplied by the technical journals, but on the purely scientific side there is risk that an undue development of specialisation, without sufficient nourishment and communication from other parts, may lead to local turgescence and inflammation, to the injury of the system and the ultimate atrophy of the parts.

In treating of the connections of physical science with other branches of science, we may either divide physical science in some systematic way, and study the connections of each division with other sciences, or begin by considering the other branches of science and see how each is connected with physical science. Without some systematic and rational method, we are sure to omit outlying and unfamiliar parts of any subject of investigation. It is possible in the compass of a short article to go over only a very small number of the various connections between physical science and science in general, and no one individual could do justice to the theme; it is only possible here to make some suggestions as to methods of systematic division of the subject, and to point out a very few of the connecting links that at present cry for strength. Physical science may generally be described as the study of the properties of matter, energy, and ether. It is divided from chemistry by being the study of each kind of matter by itself, while chemistry studies the actions of different kinds of matter upon one another. Of course no real line can be drawn, and the enumeration of the objects of physical study is for the

purpose of dividing the subject itself rather than for the purpose of dividing it from other subjects. The properties of matter and energy, of energy and ether, and of ether and matter, are the subjects of investigation in physical science. The matter and energy region is subdivided into (1) pure dynamics of solids and fluids, that branch where mathematics reigns supreme, whether we study the motions of the planets, or of vortex rings, where we deal with regular and reversible kinetic and potential energy; and (2) the study of irregular motions of heat and turbulence, the kinetic theory of gases and the turbulent motion of a liquid, the first and second laws of thermodynamics, the laws of specific and latent heats, of temperature and entropy, viscosity, and the limits of elasticity. This subdivision into energy as regular and irregular is fundamental, and pervades the whole of science; it bears on cosmology when we study the action of tide production and tidal retardation of rotation, the circulation of water up the air and down the mountains and its erosions and grindings; it bears on chemistry when we study chemical equilibrium and heat of chemical action; it bears on biology when we study the regular production of mechanical work, of electric currents, of nervous stimuli, and when we study the production of heat, the viscous resistance to flow of fluids. The relations of ether and energy are comprised in the study of electro-magnetism and light. As yet we know little about the relations of irregular energy and ether, and still less how this bears on cosmology, chemistry and biology. The bearings of electro-magnetism and light on the other branches of science are too many to enumerate and too familiar to be worth enumerating. We are yet only on the threshold of what is to be known. The connections of matter and ether are even more obscure. What is an electric current? What is a magnet? Why are some things electro-positive and others electro-negative? Why do most vegetable substances turn the plane of polarisation of light one way and animal substances the other way? Why is terrestrial magnetism so irregular, so variable? On every side weak links require

strengthening, the country requires opening up, railways and telegraphs require to be organised.

Of the three great branches of science—cosmology, chemistry, and biology—the first has benefited most by physical science. One of its most advanced branches, astronomy, is almost a dependency on physical science. Since Sir Isaac Newton's time the motions of the stars, the motion of the earth, the tides, have been almost entirely reduced to be branches of pure dynamics. Still there are outlying branches even here. The motions of meteors, the constitution of the sun, the tides themselves have not been fully explained by known physical causes. In the other branches of cosmology, geology, and geography, the connections with physical science are great, but do not at all equal in extent the connections with astronomy. Many, many outlying branches are still unsupplied with connections. To enumerate even a few of the directions in which these connecting links may be strengthened, it may be worth while suggesting investigation of the velocities of meteors by photography. All that is required is a periodic eclipsing of the plate at known short intervals of time. Any meteoric path photographed would then be interrupted at regular known intervals, and a simple calculation founded on the observed length of path photographed between the interruptions, would tell us with considerable accuracy the angular velocity of the meteor; a velocity only known now in the very vaguest way. The study of the deformation of the crust of the earth by solar and lunar gravitation is a connecting link between physics and cosmology, that requires considerable strengthening. We are told on one hand, on the highest authority, that the earth is solid to the core; and, on the other hand, that the investigations upon which this result is based have been gone over very carefully, and do not lead to that conclusion at all. Is the earth rigid? How do mountains stand? What are the causes of the earth breathings, of the motion of the pole, of earthquakes? Can glaciers erode the bottoms of rock hollows? Do we see in the periodic variations of terrestrial magnetism any

effects of internal stresses on a magnetic nucleus or a piezo-electric action on crystals in the crust? Did the moon breaking away leave the hollows the sea fills? an unlikely suggestion, or can the atmospheric circulation while the earth was mostly molten, if it ever was so and was not originally a mass of pretty cold meteors, have been intense enough to blow the scum of the earth into the continents, although the then equatorial effect of solar radiation cannot have been as great in proportion to the effects of general terrestrial temperature as they are now? What is the nature of solar circulation? With no equatorial heating its conditions differ *in toto* from terrestrial atmospheric circulation. Does the motion of sunspots show that the solar circulation is round vortices parallel to its axis, or can vortical circulation take place round other axes for any length of time? Is the state of matter inside the sun different from anything we know here owing to the enormous temperatures and pressures there? Is matter destroyed there, as has been suggested, or, more probably, are the poor atoms so tortured that, may be, one end of an atom may be miles away from its other end, and the structure like one of those proposed for the ether? Would this account for the darkness of sunspots? How are we to explain the thinness of the radiating layer round the sun, with an enormously hot and apparently opaque mass behind? What is the physical condition of nebulæ and of new stars? Spectroscopy has told us a great deal about the structure of stars and star systems, and it has similarly told us a great deal about the structure of atoms. Double lines betoken rotating stars and rotating atomic motions. We are still only on the foundations of the roads between physics and chemistry in investigating the structure of matter. Only the other day our means of investigation in the ultra-violet have been enormously extended. Whole forests of lines have been added to the spectrum of hydrogen. What are the motions these Fourier series represent? Can we sum these series? Can we invent a structure that vibrates so? Some years ago Lord Rayleigh spoke of the desirability of

studying the simpler chemical phenomena. Since then we have had the modern physico-chemical researches on electrolysis and solution, on electrical resistance and lowering of freezing points, on vapour pressures and superficial tensions in solutions. This latter question, an obvious borderland where physics touches on chemistry, deserves careful investigation. Catalytic actions, dyeing, crystallisation, diffusion, all may depend on the peculiar properties of the superficial layer between two liquids, or the layer of liquid next a solid. A good deal has been done on the electrical side of these questions—very little on the thermal and chemical sides—and yet, considering the small size of organic structures, the minute volumes and enormously extended surfaces, actions of this kind must have an important effect in organic life. The solubility of a substance in the layer of a liquid where it is in contact with another substance—liquid or solid—is sometimes quite different from its solubility in the general body of the liquid. A layer of porous solid may act as a semi-permeable membrane, and permit only a comparatively small diffusion of one of the constituents of a solution to pass through by collecting the other constituent upon its enormously extended surface layer. The physical conditions of the material within these surface layers are very different from outside. It has, for instance, been suggested that in the surface layer between a liquid and its vapour, in which some state of kinetic equilibrium holds between evaporation and condensation, all the various states represented by the sinuous part of the theoretical continuous isothermal which can be drawn, connecting the liquid and gaseous states, coexist at different depths in it. The conditions of chemical equilibrium under such abnormal circumstances can hardly be the same as within the liquid ; indeed we know that the solubility, a very important question of simple chemical equilibrium, is different within this layer. The conditions of diffusion through continuous membranes like the case of hydrocarbons diffusing through india-rubber and other similar cases of semi-permeable membranes, may be more strictly chemical questions, but being so closely

connected with physical diffusion, and with the physical theories of the constitution of matter, they may rightly be noticed as on the connecting road between physics and chemistry. In this same connection it is interesting to consider the way in which electrolysis alters diffusion. Both in gases and liquids it appears as if the ions were carried by an electric current through metallic plates. It has been observed that the negative glow can penetrate thin metallic plates even into the air outside the exhausted tube. This certainly looks as if the ions were able, with the assistance of the electric current, to pass through the metal. It has also been found that electrolysis in liquids can take place through a thin metallic plate while a thick one has the electrolytic ions deposited on its surface or actively attacking its substance. If metallic plates can act so there seems every reason to expect that other diaphragms may act similarly. It appears as if electrolysis can be forced through a very short metallic layer. As if Grothus chains of metal and ion can hand on the ions for a short distance into the metal, but that ordinary metallic conduction rapidly sets in. This would all lend support to the theory that ordinary metallic conduction is a disorganised kind of electrolysis; disorganised by a rapid diffusion which restores the bonds as rapidly as they are broken down by the electrolysis, so that no continuous vection takes place, except as it would now appear through a very short distance. That organic membranes can do something akin to conduct metallically seems certain from the possibility of accumulating a high electric pressure by means of numerous cells in electrical fishes. By merely repeating a number of liquid contacts through porous diaphragms it is not possible to accumulate a high electric pressure. It seems as if some unstable body were set free by the nervous stimulus which probably diffuses through some septum, producing thereby an electric pressure, which may be transmitted by some means akin to conduction to the next cell. It may be, of course, that this diffusion through the cell wall is what is akin to conduction, and that the electrolysis is what takes place through the other septum. It must, however, also be

recollected that the formation of a hemihedral crystal is very probably accompanied by electric pressure, and a sudden crystallisation might be the source of the discharge. That some crystalline structure seems visible in muscular fibre might lend plausibility to this suggestion, though the enormous prevalence of diffusion and superficial layer phenomena in organic bodies makes the former a more probable line of investigation, muscular contraction itself being either a diffusion or superficial tension phenomenon. In any case, the openings for means of communication between physics and biology are evidently innumerable, and many of them ripe for opening up. The curious preferences for dyes shown by organic bodies is possibly another example of these superficial affinities, where the question of relative solubility in the superficial layer depends on how much the superficial tension is changed by the body dissolved, and so may depend not only on the solvent but on the nature of the neighbouring surface. Many interesting questions depending on the size of molecular groups, which we learn from the theory of gases, are of great biological interest. Why do small solid particles, suspended in a liquid, keep continually moving about? If this motion be not part of the heat energy of the liquid, where does the energy required to keep them moving come from? If it is part of the irregular heat energy of the liquid, it would appear as if the microscopist, with a fine needle, might act the part of a Maxwelian demon, and by a proper sorting of the particles frustrate the second law of thermodynamics. It has been suggested that this is actually done by minute organisms. This does not, however, at present look like a very hopeful supply of work, though there is no knowing what we may come to when coal fails us. In any case, this whole subject of the possible structural complexity of visible particles is an important road between physics and biology, about which enough is known to make advance possible. The road through the special senses of sight and hearing has been nobly pioneered, though many branches of it require much strengthening. The whole subject of electric stimuli, the electric currents

accompanying organic changes in muscles, nerves, glands, etc., wherever a directed action takes place, is a magnificent trunk line of connection between physics and biology. It is at present dreadfully encumbered by a medico-therapeutic jargon of Galvanisation, Faradisation, Franklinisation. What is required is measurement. Measurement of strength of current, distribution of current, duration of current, variation of current, in fact, of the nature of the current and not a vague description of how it was produced. A Leyden jar discharge, the so-called Franklinisation, may be short or long, continuous or oscillatory according to circumstances. It is the nature of the current and not its mode of generation that is of importance. A poor nerve only knows what passes through it. Unless the patient see and is nervously affected by the presence of a big electrical machine the nerve never knows what the source of its agony is.

Modern investigations on the nature of light will probably bear fruit in connection with biology, chemistry, and cosmology, though the connecting roads are at present but suggested tracks. It has been suggested that the rods and cones in the retina are about the sized structure that would, by ordinary conduction, resonate to the electro-magnetic vibrations that affect our eyes. The transparency of these structures would require the vibration to be a displacement vibration and not a conduction current, or else that the current was conducted round the cones by the black pigment in which they are immersed, and whose blackness was evidence of its conducting power. Whatever is the true explanation, the matter seems capable of investigation. The whole field of chemical optics and electrolysis is open for investigation. Why does light cause combination of hydrogen and chlorine? Is this and allied phenomena, in which it would seem that the primary action was the breaking down of a molecular group, connected with ordinary electrolysis? Here, certainly, we want more light to see the road. Do magnetic forces, as well as electric ones, come into play in building up molecules and solids? If Mr. Larmor's suggestion that atoms are

little closed electric currents be true, these magnetic forces should have some interatomic effects as well as the electric twist he supposes superposed upon them. These complications seem, however, required by the apparently more complicated nature of general chemical actions than the particular case of simple electrolytic ones. In cosmology we have innumerable suggestions as to the causes of magnetic storms, auroræ, comets' tails, coronal streamers, zodiacal light, all depending upon various electro-magnetic actions. Some, such as the direct production of magnetic storms by electro-magnetic changes on the sun, seem disproved by the enormous expenditure of energy required; but others, in which the electro-magnetic actions are due to streams of ions in particular directions crossing the earth's way, seem deserving of consideration.

The greatest problems at present before physical investigators are the structure of ether and matter. We can hardly doubt that they are dynamically constructed. They are every day more conclusively shown to be dynamical systems, subject to the laws of momentum, of energy, of action and reaction. Are they so in their minutest parts? There seems little doubt but that they are. If so, what is their structure? Is the fascinating suggestion of vortex rings in a perfect liquid or in a MacCullagh medium capable of explaining the phenomena of matter? What about the difficulties involved in the momentum being greatest when the velocity is least? Is it a more helpful view to be content for the present with those horrible fictions of the pure mathematician, small hard particles, and to treat combinations as planetary systems with a measurable moment of momentum as well as internal energy? We want to get a road opened up into these dark continents. We want to know the structure of matter and its internal motions, and we look to the physical investigator to study spectra, the laws of motion, the sizes of molecules, their internal motions. We look to the chemist to measure the forces between them, their modes of combination, their structure when combined, and how that structure affects their properties, physical and

chemical. We hope some day to know so much of these internal motions and of these structures that we may be able to discover the structure in the brain that betokens memory and the motions underlying great thoughts, goodness, love. We may then hope to form some dim scientific judgment of the thoughts underlying creation. We may be able to tell what thoughts underlie the motions of a solar system or the development of a race.

G. F. FITZGERALD.

# THE NEW THEORY OF SOLUTIONS.

## DIOSMOSE.

MANY of the investigations of the older physiologists were concerned with the passage of liquids through animal membranes. If an aqueous solution were introduced into a vessel, the base of which consisted of a piece of bladder, on immersing the vessel in water until the levels of liquid within and without were the same, numerous observations established the fact that both water and dissolved substance began to traverse the membrane. In the same apparatus the rates at which these movements took place varied with the concentration of the solution and the nature of the dissolved substance, but it invariably happened that water passed through the membrane more rapidly than the saline substances present in the solution. For this reason the volume of the solution began to increase. Pressure thus began to rise on the solution-side of the membrane, and continued to augment until it reached a limiting value. Such phenomena received the name of *endosmose*, the term *exosmose* being applied to what occurs when water is placed within and solution without the vessel, and the apparatus employed was termed by Dutrochet an *endosmometer*.

The most noteworthy attempt to obtain quantitative measurements of what was taking place in these experiments was made by Jolly. In his method the endosmometer is kept immersed in water which is constantly renewed, consequently endosmose only reaches its limit at the instant when all the dissolved substance has escaped and the apparatus contains only pure water. When this state of things is attained, the ratio of the weight of water which has passed into the vessel to the weight of dissolved substance which has escaped Jolly termed the endosmotic equivalent of the substance with reference

to the membrane employed. The magnitudes of this quantity for different dissolved substances have no very precise meaning, however, for besides being affected by the pressure differences which are set up upon the membrane during endosmose they are largely influenced by the nature of the membrane. It appears that the kind of membrane used, or with the same membrane, its thickness or freshness modifies the results obtained. Even the direction of endosmose is of importance in some cases : thus water passes more readily outwards through eel's skin, more readily inwards through frog's skin.

### OSMOSE.

For these reasons it is evident that when animal bladder is employed the behaviour of dissolved substances towards permeable partitions is to a large extent masked by the specific effect exerted by the membrane. In more recent times this disturbing influence has apparently been entirely removed and the phenomena have been considerably simplified by the use of membranes artificially prepared. The credit of directing attention to the properties of these artificial membranes is due to M. Traube. Working still from a physiological stand-point he discovered, in 1867, that several membranous precipitates although they may be freely traversed by water differ from animal membranes in the important particular of presenting a barrier to the passage of certain dissolved substances. Traube showed, for instance, that if a quantity of copper sulphate solution be aspirated into a narrow glass tube, on cautiously dipping the tube into a solution of potassium ferrocyanide, and allowing the two solutions to come into contact, a membranous precipitate of copper ferrocyanide may be formed, shutting in the contents of the tube. This membrane was found to be impermeable to the dissolved substances which produced it and also to certain other substances which could be added to the original solutions. Such a membrane, which is permeable only to solvent

but not to dissolved substance, is now spoken of as a *semi-permeable* membrane and the phenomena to which it gives rise when it separates a solution from pure solvent are commonly termed *osmose*, whilst phenomena such as those involved in the older experiments in which dissolved substance as well as solvent pass through the membrane are referred to as *diosmose*.

## OSMOTIC PRESSURE.

Traube noticed that different pressures were set up on opposite sides of the precipitates obtained in his experiments, but as the septa were much too fragile to withstand any appreciable difference of pressure he was unable to make quantitative observations. Such results were first obtained in 1877 by W. Pfeffer, who put into practice the happy idea of depositing the precipitate within the wall of a small porous clay cell such as that employed in a voltaic battery. If such a cell be lowered into a solution of copper sulphate, while at the same time a solution of potassium ferrocyanide be poured into its interior, the solutions meet within the wall of the cell. Little diaphragms of copper ferrocyanide are thus formed which stretch across the interstices in the wall, sufficient support being thus afforded to enable the precipitate to withstand a pressure of several atmospheres.

After such a cell has been washed free from the liquids producing the membrane, on introducing into it a quantity of solution and lowering it into pure water, just as in the older experiments water passes into the solution and pressure begins to increase on the solution-side of the membrane. And if instead of allowing the head of liquid to rise considerably within the cell, the top of the latter be closed in, a quantity of air being thus imprisoned over the solution, pressure may be established by the compression of this quantity of air, and the value of the pressure may be ascertained by having the air-enclosure connected with a manometer.

The striking result here arrived at is that water enters the cell until the pressure difference reaches a maximum,

and when this maximum is attained there is equilibrium between solution and solvent—the concentration of the solution, which was, of course, lessened by the entrance of solvent, and the pressure remain the same. When this constant state of things is established, the excess of pressure on the solution-side of the semi-permeable membrane over that on the solvent-side, is termed the *osmotic pressure* of the solution.

## ORIGIN OF THE NEW THEORY.

It is to this experimentally ascertained magnitude—the osmotic pressure—which is in the main the outcome of the labours of physiologists, that the new theory of solutions, founded by van't Hoff, owes its origin. As van't Hoff pointed out, the great practical advantage which arises from the experimental demonstration of the existence of osmotic pressure, no matter what its real nature may be, lies in the fact that it enables the laws of thermodynamics to be applied to solutions. If we enclose a quantity of solution in a cylinder fitted with a piston, and if the walls of the cylinder be semi-permeable, on immersing the cylinder in water, the latter will begin to enter the cylinder, and pressure will begin to rise within it. If, however, we compress the solution by means of the piston, entrance of water will be retarded, and when the pressure exerted by the piston is equal to the osmotic pressure, there will be equilibrium between solution and solvent. Moreover, by altering the pressure on the piston, the concentration of the solution may be altered just in the same way as a gas may be rarefied or compressed, with the difference in the case of the solution that change of volume is produced by the passage of water through the semi-permeable membrane. By taking care that the pressure on the piston is just equal to the opposed pressure the above processes may be made reversible, and it is possible to perform with a solution a reversible cycle of operations just as Carnot did with a gas. In this way solutions as well as gases may be treated thermodynamically. From such considerations

van't Hoff showed that if a solution is so dilute that on communicating heat to it the heat is exclusively employed in doing external work, then, if the concentration of the solution remains the same, the osmotic pressure should be proportional to the absolute temperature. Such experimental data as were available were not opposed to this conclusion, which is now spoken of as *Gay Lussac's law for dilute solutions*, as it is similar to the well-known law of Gay Lussac connecting gaseous pressure at constant volume with the temperature. Now, Pfeffer's observations on sugar showed that at constant temperature osmotic pressure was approximately proportional to the concentration. Here there was indication that a *law analogous to that of Boyle held for dilute solutions*, since Boyle's law for gases may be expressed by stating that at constant temperature pressure is proportional to the mass of gas per unit volume, that is, to the concentration.

The most striking indication, however, of the closeness of the relation between solutions and gases was obtained by comparing the magnitude of the osmotic pressure of a sugar solution with that of a gas. Pfeffer found that at 6°·8 the osmotic pressure of a one per cent. sugar solution was ·664 atmospheres. The pressure of a volume of hydrogen equal to that of the solution, and containing the same number of molecules as there are molecules of sugar in the solution, is ·665 atmospheres. The values of the two pressures are, therefore, almost *identical*. This identity of the values for the osmotic and gaseous pressures, the theoretical and practical support to the idea that they obeyed the same laws, led van't Hoff to the conclusion that both are essentially of the same nature, that both have the same origin. The pressure of a gas is due to impacts of its molecules on the walls of the containing vessel, and according to van't Hoff the osmotic pressure of a solution is the result of the impacts of the molecules of the dissolved substance on the semi-permeable membrane, because when equilibrium results between solvent and solution, the impacts of the molecules of the solvent are equal and opposed,

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and may, therefore, be neglected. Entrance of water into the cell is to be regarded as brought about by the attraction which is exerted by the dissolved substance. Indeed, it was the endeavour to obtain a measure of such attractive forces and to investigate their bearing on problems in chemical mechanics which first caused van't Hoff to direct his attention to Pfeffer's observations.

If, as this reasoning indicates, osmotic pressure is of kinetic origin, there ought to be a proportionality between the number of impacts per unit time of the molecules of the dissolved substance on the semi-permeable wall and the number of molecules per unit volume of solution, that is, the osmotic pressure ought to be proportional to the concentration. The above hypothesis as to the nature of osmotic pressure thus supports the validity of Boyle's law as applied to dilute solutions.

The identity of the osmotic pressure of a given volume of sugar solution with the gaseous pressure of an equal and equimolecular volume of gas, was regarded by van't Hoff as but a particular instance of the applicability to dilute solutions of an *hypothesis similar to that of Avogadro.* The validity of this application he established thermodynamically, taking the particular case of a soluble gas obeying Henry's law, and as Pfeffer's observations showed that sugar solutions conformed to the hypothesis, the latter was transferred to solutions in general. For these reasons it is asserted that equal volumes of dilute solutions at the same temperature and under the same osmotic pressure contain the same number of molecules of dissolved substance. Moreover, this number of molecules is the same as that in an equal volume of gas at the same temperature, and under a pressure equal numerically to the osmotic pressure of the solution.

## THE APPLICATION OF GASEOUS LAWS TO DILUTE SOLUTIONS.

On the new theory of solutions, therefore, a dissolved substance may be treated as if it were gaseous. Replac-

ing gaseous pressure by osmotic pressure, gaseous laws may be employed to express the behaviour of dissolved substances when in dilute solutions. In this condition, it has to be noted that dissolved substances so far resemble gases that the actual volume of their molecules is negligable as compared with the space which they inhabit, that is, the volume of the solution, and further that their energy is independent of the volume—there is no thermal change in dilution. The validity of the application of the gaseous laws to solutions can be tested by other means than by observations on osmotic pressure. It can be shown, apart from any theory as to the mechanism of osmotic pressure, that solutions in the same solvent, having the same osmotic pressure, must have the same vapour pressure and boiling point and the same freezing point. But according to the gaseous analogy, solutions having equal osmotic pressures, or *isotonic solutions* as they are called, must have the same molecular concentration; hence, according to the analogy, solutions having the same freezing point and vapour pressure must contain per unit volume the same number of dissolved molecules. Moreover, assuming the validity of Avogadro's hypothesis as applied to solutions, van't Hoff has deduced thermodynamically how the vapour pressure and freezing point of these equimolecular solutions should vary from solvent to solvent. Evidence as to the validity of the analogy can thus be obtained from measurements on vapour pressure and freezing point, measurements much more easily carried out than the difficult observations on osmotic pressure.

It is proposed in the present articles to summarise the results of the main researches which have been made in connection with the new theory of solutions, and in treating the subject-matter attention has been paid to the exceptional behaviour of certain solutions.

The laws which have been applied to dilute solutions are to be regarded as limiting laws which would be obeyed by an ideal solution. And just as certain gases deviate from the ideal gaseous laws, some containing fewer and others more molecules than Avogadro's

hypothesis demands, precisely similar exceptions have been recognised in the case of solutions. In some solutions *association* of simple dissolved molecules is supposed to take place, while in a whole class of solutions, namely, those of salts, strong acids and bases, all of which are electrolytes, the dissolved molecules are supposed to undergo *dissociative* changes resembling in many respects those occurring in the case of gases.

To begin with, we will deal with *non-electrolytic* or *indifferent* solutions, and further with those in which no association of molecules is supposed to take place.

## OSMOTIC PRESSURE.

*Absolute Measurements.*—Measurements of osmotic pressure have only been made for aqueous solutions, and only three observers, namely Pfeffer, Adie, and Tamman, have obtained absolute measurements. Adie used Pfeffer's method, Tamman employed a new method, which consists in separating two solutions by a semi-permeable wall, and altering the pressure on one of them, till neither loses or gains water. The external pressure thus applied is evidently equal to the difference of the osmotic pressures of the solutions, and by adding a soluble substance to one of the solutions, its osmotic pressure may be obtained in terms of the adjustable external pressure. The method is, however, very troublesome in practice.

As regards the substances examined, Pfeffer, who investigated the subject from a botanical point of view, used solutions of cane sugar, dextrin, gum-arabic, and the nitrate, sulphate, and tartrate of potassium. Adie used salt solutions only, and Tamman studied cane sugar and isobutyl alcohol when dissolved in copper sulphate solution.

*Relative Measurements.*—A large number of observations on osmotic pressure have been made by relative methods. De Vries in 1884 described three botanical methods of obtaining isotonic solutions. Of these, the

most important make use of the phenomena of plasmolysis. It appears that the living protoplasm of a vegetable cell behaves as a semi-permeable membrane. It seems to allow water to freely pass through it, whereas it retains the sugar and saline constituents of the cell sap. If such a cell be immersed in water it becomes turgid, and the cell wall may eventually be ruptured, owing to the osmotic pressure of the cell sap being set up within it. If the cell, on the other hand, be immersed in a strong aqueous solution, the cell sap loses water. The protoplasmic envelope which in the normal condition is closely applied to the cell wall contracts, and thus within the cell wall vacant spaces are formed which become filled with transparent solution. On using cells with coloured contents it is easy to observe under the microscope when this entrance of solution takes place, and, by having a series of solutions of gradually diminishing concentrations, and immersing in each preparations of living cells from the same plant, it is possible to ascertain the strength of solution at which entrance of solution within the cell wall or plasmolysis just ceases to occur. This particular solution will be isotonic with the cell sap, as neither gains or loses water when separated by the semi-permeable protoplasm of the living cell. Solutions of different substances which are isotonic with the sap of cells from the same plant may in this way be obtained, and which may, therefore, be regarded as isotonic with one another.

The normal concentration of the cell sap may be altered by plasmolysing the cells in a standard solution of known concentration. Solutions of other substances may then be found in which the state of plasmolysis remains unchanged, and these will evidently be isotonic with the standard. Several series of solutions of different substances, isotonic with different standards, may also be obtained by using cells from plants of different species.

Tamman obtains isotonic solutions by allowing a drop, say of copper sulphate solution, to fall into a solution of

potassium ferrocyanide, and adjusting the concentrations of the solutions till the copper sulphate enclosed within the semi-permeable precipitate, which is at once formed around the drop, ceases to lose or gain water. Whether water does pass to or from the drop may be conveniently ascertained by finding by the use of Topler's apparatus if the refractive index of the liquid near the drop varies. Another substance may be added to A, one of the membrane-forming solutions. The isotonic concentration of B, the other membrane former, is then found. On the assumption that the osmotic pressure of the substance is added to that of A, the concentration of B isotonic with the substance may readily be ascertained.

A remarkable method of obtaining isotonic solutions, inasmuch as *no semi-permeable membrane is present*, consists in the use of red blood corpuscles. If defibrinated blood be introduced into water or a weak aqueous solution, the colouring matter of the corpuscles becomes uniformly diffused throughout the liquid which is tinted reddish-brown. In a strong solution the corpuscles settle to the bottom of the containing vessel, leaving the upper layers of liquid colourless. Solutions to which the blood corpuscles are just on the point of communicating a red tint are isotonic. The values of the concentrations of isotonic solutions obtained in this way, using the blood of the ox, agree satisfactorily with the results given by De Vries. Different series of isotonic solutions may be obtained by using the blood of different animals. Hamburger, to whom this method is due, finds that in a dilute solution water enters the corpuscle until the osmotic pressure of its contents is equal to that of the solution. During this process a quantity of dissolved substance also enters the corpuscle, which apparently gives up to the solution an *isotonic* amount of dissolved material from its own contents. If the amount of water entering is sufficiently large, the corpuscle will be ruptured and the solution will be coloured, and the concentration of the contents of the corpuscle at which rupture first occurs is the standard concentration with which the surrounding solutions are

compared. From this peculiar property, whereby the corpuscle, although losing part of its contents, takes up an isotonic amount from the solution, it is possible to obtain isotonic solutions even in the absence of a semi-permeable membrane.

By studying the electrical excitability of frog's muscle (Nasse) or even the motions of bacteria (Wladimiroff) in different solutions, attempts have been made to arrive at the concentrations of isotonic solutions.

Most of the relative measurements of osmotic pressure relate to electrolytic solutions.

*Boyle's law for dilute solutions.*—The only absolute measurements on a well-defined indifferent substance which can be used to test this law are those of Pfeffer on sugar. If the law holds, at constant temperature the ratio of the osmotic pressure P to the concentration C should be constant. For a sugar solution at temperatures between 13°·5 and 14°·7 Pfeffer gives the following values :—

| C in per cents. | P in cm. of Mercury. | P/C. |
|---|---|---|
| 1 | 53·5 | 53·5 |
| 2 | 101·6 | 50·8 |
| 2·74 | 151·8 | 55·4 |
| 4 | 208·2 | 52·1 |
| 6 | 307·5 | 51·3 |

Although the values of P/C vary by some 10 per cent., considering the difficulty of the observations their constancy is satisfactory. The above measurements were made with a membrane of copper ferrocyanide. Much lower values for the osmotic pressure were obtained for the same sugar solution when a membrane of Prussian blue or calcium phosphate was employed, and these facts have been cited as indicating that even with artificial membranes, just as with animal bladder, the nature of the membrane affects the results. It is easy to show theoretically, however, as Ostwald has pointed

out, that if the membrane is really semi-permeable its nature can have no influence on the value of the osmotic pressure. It is concluded, therefore, that those membranes giving the lower values were not quite firm, or not quite impermeable to dissolved substance, and the highest value of the osmotic pressure is regarded as being nearest the truth. Even copper ferrocyanide does not seem to be quite impermeable to sugar, as some of Pfeffer's results are considerably lower than those given in the table. The variations in the value of P/C may be in part attributed to this cause.

Evidence in support of Boyle's law, as applied to solutions, is also furnished by the relative methods, as the ratios of the concentrations of two isotonic solutions is in general the same no matter what the absolute concentrations may be. From the nature of the methods, the constancy of the ratio can only be investigated over narrow limits of concentration.

*Gay Lussac's law for dilute solutions.*—Pfeffer's observations on a one per cent. sugar solution, limited though they are, supply the most extensive data for testing the law. In the table are given the results of three series of observations (*a*, *b*, *c*), carried out in different porous cells, *t* is the temperature of observation, P the pressure and R the ratio of P to the absolute temperature. This ratio should be constant if the law is obeyed.

| | *t*. | P in cm. of Mercury. | R. |
|---|---|---|---|
| *a* | 14·2 | 51·0 | ·178 |
| | 32·0 | 54·4 | ·178 |
| *b* | 6·8 | 50·5 | ·180 |
| | 13·7 | 52·5 | ·183 |
| | 22·0 | 54·8 | ·186 |
| *c* | 15·5 | 52·0 | ·181 |
| | 36·0 | 56·7 | ·183 |

The ratios vary by some 4 per cent., and since the

temperature range over which they extend is but some 30°, the pressure alteration being only 6·2 cm., the results do not furnish very decided support to the law.

By the use of blood corpuscles, Donders and Hamburger found that solutions—for the most part electrolytic—which were isotonic at 0° were still isotonic at 34°. This result indicates that the effect of temperature on osmotic pressure is the same for solutions of different substances; it gives no clue, however, as to the law of the temperature change. It is evident that the experimental support to the application of Gay Lussac's law to dilute solutions cannot be regarded as very strong. The range over which the observations extend is too short to admit of the accurate determination of the law expressing the variation of osmotic pressure with the temperature.

*Avogadro's hypothesis as applied to dilute solutions.*—According to this hypothesis equal volumes of solutions which at the same temperature have the same osmotic pressures should contain the same number of molecules, and consequently equimolecular solutions should be isotonic. De Vries was the first to show that this was the case. By his methods he found the isotonic molecular concentrations of two substances A and B, that is, the concentrations for equal osmotic pressures. Assuming the proportionality of osmotic pressure and concentration, the reciprocal of the ratio of the above concentrations is the ratio of the osmotic pressures of A and B for equimolecular concentrations. De Vries took potassium nitrate as the standard substance B, and put its osmotic pressure equal to 3, and the osmotic pressure of a substance referred to that of nitre as 3 he termed its *isotonic coefficient.* The isotonic coefficients of indifferent solutions should, according to the hypothesis, be the same. Very few indifferent substances have been investigated. The three methods (I., II., III.) used by De Vries gave the values for the isotonic coefficients represented in the table. In column IV. is a result obtained by the use of blood corpuscles.

| | I. | II. | III. | IV. |
|---|---|---|---|---|
| Urea . . . . | 1·70 | — | — | — |
| Glycerin . . . | 1·78 | — | — | — |
| Invert Sugar . . . | 1·88 | — | 1·84 | — |
| Cane Sugar . . . | 1·81 | 1·95 | 1·84 | 1·72 |

The isotonic coefficients of the four substances as found by the different methods are approximately equal.

Tamman by his optical method obtains results for six indifferent substances. He uses potassium ferrocyanide as standard. If $n$ be the gram molecular weights of this salt dissolved in 1000 gr. of water he finds for $n = 1$ and for $n = 3$ the ratios R of the isotonic molecular concentrations of the indifferent substances. His results are as follows :—

| | R. | |
|---|---|---|
| | $n = 1$. | $n = 3$. |
| Ethyl Alcohol . . | ·45 | ·45 |
| Cane Sugar . . . | ·40 | ·40 |
| Salicin . . . . | ·42 | — |
| Chloralhydrate . . | ·46 | ·45 |
| Ether . . . . | ·45 | — |
| Urea . . . . | ·50 | — |

In general, the above results support the idea that equal volumes of indifferent isotonic solutions are equimolecular.

In order to test the validity of Avogadro's hypothesis in the case of the absolute measurements on sugar the osmotic pressures have to be compared with the corresponding gaseous pressures. The following table gives the comparisons of the osmotic pressure P at different temperatures $t$, with the gaseous pressure P′ calculated by the equation $P' = 49{\cdot}27\ (1 + {\cdot}00367t)$. This equation gives the pressures which would be exerted by a volume of gas equal to that of the solution and containing the

same number of molecules as there are of dissolved sugar.

| $t$. | P in cm. of Mercury. | P′ in cm. of Mercury. |
|---|---|---|
| 6·8 | 50·5 | 50·5 |
| 13·7 | 52·5 | 51·7 |
| 14·2 | 51·0 | 51·8 |
| 15·5 | 52·0 | 52·1 |
| 22·0 | 54·8 | 53·2 |
| 32·0 | 54·4 | 55·0 |
| 36·0 | 56·7 | 55·8 |

In no case is the difference between observed and calculated numbers considerable.

Now it has been shown by the relative methods that solutions of indifferent substances which at the same temperature have the same osmotic pressure as a sugar solution contain, per unit volumes, the same number of dissolved molecules as the sugar solution. Hence it follows that these substances as well as cane sugar conform to Avogadro's hypothesis as applied to solutions. Equimolecular solutions of each at the same temperature exert the same osmotic pressure, and this pressure is the same as that which the dissolved substance would exert if it were gasified and if it occupied at the same temperature a volume equal to that of the solution.

J. W. Rodger.

*(To be continued.)*

# INSULAR FLORAS.

## PART I.

SINCE the publication of the botany of the voyage of H.M.S. *Challenger*, in 1885, there has been no general review of the subsequent botanical literature relating to insular floras. It is true that recent discoveries have not added materially to our knowledge of the composition and probable origin of the vegetation of remote islands or groups of islands; yet, much has been accomplished in working out the details of their floras, both in description and illustration, as well as in observation of the means of dispersal of plants. A condensed summary of what has been done in this branch of botany is perhaps the most useful way of treating the subject in the limited space that can be devoted to it here. Unimportant contributions must necessarily be left out of consideration.

Beginning with Eastern Polynesia, there is now a complete and critically elaborated account of the flora of the Sandwich Islands, in English,[1] though unfortunately, in consequence of the untimely death of the author, the part dealing with the relationships of the flora consists of mere fragmentary notes and observations. Nevertheless, the author having lived twenty years in the islands, and having during that period spent much of his time in the elucidation of the flora, these notes merit our serious attention. In all 999 species of vascular plants are described, and these are assigned to 365 genera, but it is estimated that 115 species have been introduced since the discovery of the islands, and that some twenty-four others were previously introduced by the natives. The latter are all of economic value, and, although now spread all over Polynesia, have probably spread with the migrations of the inhabitants from their original homes, largely from the Malay Archipelago.

[1] *Flora of the Hawaiian Islands*, W. Hillebrand, 1888, 8vo, xcvi. and 673 pages, with 4 maps.

Among these plants regarded as of exotic origin are: *Calophyllum*, *Paritium*, *Lagenaria*, *Cordia*, *Cucurbita*, *Artocarpus*, *Broussonetia*, *Aleurites*, *Piper*, *Colocasia*, *Musa*, *Saccharum*, *Dioscorea*, etc., in fact nearly all those necessary to the existence or comfort of the inhabitants. After making the foregoing deductions, there remain 860 species belonging to 265 genera, which may reasonably be regarded as indigenous; in other words, as having reached or developed in the islands, independently of human agency. Of these 860 species, 653 are endemic or peculiar to the islands; and there are forty endemic genera. Of these no fewer than 180 species and six genera are described by Hillebrand for the first time. It is computed that 81·42 per cent. of the phanerogams are endemic, and, taking the dicotyledons alone, no less than 85·62 per cent.; yet the author is wrong in stating that this proportion is much higher than in any other country. In West Australia, for example, eighty-five per cent. of the whole specific phanerogamic flora is endemic, and in St. Helena, thirty-seven out of the thirty-eight indigenous flowering plants are endemic. With regard to the origin of the flora, the author recognises the inadequacy of oceanic currents, and he found no evidence of an earlier terrestrial immigration. He also specially emphasises the fact that the Hawaiian Islands are the only Polynesian group containing a large proportion of indigenous plants having American affinities. This is strongly exemplified in the numerous and prominent endemic Compositæ and Lobeliaceæ.

The author describes five zones of vegetation, which ascends to altitudes of 10,000 to 11,000 feet on some of the mountains; but, as this work has been so long in the hands of botanists, it does not seem desirable to give fuller particulars.

There are further contributions to the botany of Eastern Polynesia, especially of the islands under French protection,[1] and of these combined with the whole of

[1] *Flore de la Polynésie Française*, E. Drake del Castillo, 1893, 8vo, xxiv. and 352 pages.

Polynesia proper.[1] The illustrations are particularly useful, and it also contains an enumeration of all the plants known to the author from the whole of Polynesia, with the general distribution of each species. This is doubtless very nearly complete, so far as the French islands are concerned, yet it is evident that the author was not well acquainted with the literature of recent discoveries in Central and Western Polynesia. Still, as the only consolidation of the more important works, it is most valuable. The plates, too, are admirable, and a great acquisition to previously existing published delineations of Polynesian types. One cannot but regret, however, that the drawings of the Forsters, Solander, Parkinson, and other members of Cook's voyages at the British Museum were never published.

The French islands, of which the plants are described in the former work, are the Society, Marquesas, Pomotou or Low, the Southern or Tubuai, and Wallis Islands—the last being far west of the others, to the north of, or rather in, the Tonga group. Of these groups, the Society Islands are the most important, and Tahiti or Otaheite is the largest and loftiest island of the group, rising to nearly 7000 feet in its highest part, and it is in this group and island that a very large majority of the endemic forms are concentrated. Out of a total of 588 vascular plants, including a considerable number of undoubtedly introduced species, the author records 161 as peculiar to French Polynesia, and about 100 as peculiar to the Society Islands. But several of the most striking types, hitherto regarded as Tahitan, have recently been discovered in Western Polynesia, an example of which is cited below. The cause of this misconception concerning the distribution of certain Polynesian types, is the extreme rarity of individuals of many species, even in some known instances where they inhabit distant islands. But most of the endemic species of the Society Islands and the Sandwich

[1] *Illustrationes Floræ Insularum Maris Pacifici*, E. Drake del Castillo, 1886-1892, 4to, 458 pages and 50 plates.

Islands, as well as of the Galapagos, are confined to single islands, and often, we are assured, by competent explorers, to very restricted areas and easily counted individuals. This affords a reason why the botanists of Cook's voyages failed to obtain nearly complete collections of the plants of Tahiti, though much time was spent there. Subsequent English collectors have made fresh discoveries, yet they have by no means exhausted the flora. French collections, as might be expected, are much richer, especially those made by persons actually resident in the islands; but they want a number of species existing in the English collections. This excessive rarity of individuals of the endemic element is not satisfactorily accounted for by the destructive effects of cultivation and the struggle with introduced plants of excessive reproductive powers combined, because many of them would appear to inhabit localities where they are neither exposed to direct destruction nor to competition. It is one of the problems to be studied on the spot. Reduced reproductive power may explain the phenomenon; but local investigation should reveal the real cause. What is certain, some of the most highly differentiated forms of vegetable development still linger on in remotely distant localities. *Lepinia*, a genus of Apocynaceæ,[1] having one of the most remarkably constructed fruits in the whole range of the vegetable kingdom, was discovered in Tahiti by the French collectors Lepine and Vesco in 1847, and by Nadeaud, a writer on the botany of the island, in 1856; but, as far as can be ascertained, it exists in no English collection from the island; yet, in 1890, the Rev. R. B. Comins collected specimens of the very same species in the Solomon Islands, some 3000 miles to the westward. No intermediate locality is known; and, to all appearance, it is one of the least likely of plants to be conveyed a distance by any of the ordinary means of dispersal. In the flowering stage the carpels of the ovary of this plant are small and apparently consolidated, but having the four

[1] *Annales des Sciences Naturelles*, 3me série. xii. p. 194, t. 9.

carpels forming the fruit on long slender stalks joined at the tips only. Returning to the numbers in Drake del Castillo's table showing the general distribution of the plants inhabiting French Polynesia: besides the 161, or thereabout, peculiar to those islands, 123 others do not extend beyond Polynesia, making 284, or nearly half of the total peculiar to Polynesia. With regard to those extending beyond Polynesia (including Melanesia and Micronesia), 297 belong to the Indo-Malayan region, and only seven to other regions. The almost total absence of Australian types is remarkable; but what is more remarkable, the absence of such types is almost as great in Central and Western Polynesia, where considerable explorations have been made during the last few years. The Tonga or Friendly Islands have been much visited from Cook's time onward; yet, until recently, no attempt had been made to give a general account of the flora. This has now been done.[1] Considering the small areas and the inconsiderable elevations of the higher islands, there is a fairly varied flora, including some endemic forms. Taken as a whole the flora may be termed Fijian; many of the plants being common to the two groups and the Samoan or Navigator's Islands to the north, with strong Malayan affinities. *Melicytus ramiflorus*, a New Zealand shrub belonging to the Violaceæ, also found in Norfolk Island, is one of the recent discoveries in the Tonga Islands; and perhaps the only element in the flora indicating any connection between the two floras. But it has a baccate fruit, and its presence in Tonga may be due to the agency of birds.

Allusion has already been made to the discovery of a highly curious Tahitan tree in the far distant western Solomon Islands. Dr. H. B. Guppy and the Rev. R. B. Comins have collected many other singular plants in this group,[2] and there is evidence of the existence of a pro-

[1] "Flora of the Tonga Islands," W. Botting Hemsley, in *Journ. Linn. Soc.*, xxx., 1894.

[2] "New Solomon Islands Plants," W. Botting Hemsley, in *Annals of Botany*, vol. v., 1891.

bably rich endemic element on the mountains of the interior of the larger islands. A rough list of the plants collected by Dr. Guppy has appeared,[1] and in spite of the fragmentary character of many of the specimens, there was sufficient material to establish several new genera, and a number of new species; and many still remain undescribed. *Cominsia Guppyi*[2] is a remarkable new genus of the *Scitamineæ* allied to *Phrynium*, and characterised by a very long corolla-tube and singularly rugose seeds. Another specially noteworthy novelty is a new genus of Pandanaceæ[3] collected by Dr. Guppy on the highest peak of Fauro Island, about 1500 feet above sea level. It is a tree fifty feet high, with an unbranched trunk, long, narrow almost unarmed leaves, and a much-branched spadix of female flowers three to four feet long. Dr. Beccari collected imperfect specimens of the same tree on the north-west coast of New Guinea.

Not less remarkable is the new sapotaceous genus *Chelonespermum*.[4] The large, curiously formed dorsiventral seeds of one or two species had been known for years, but neither flowers nor fruit; and it was not till 1879, when Mr. Horne, late director of the Mauritius Botanic Garden, brought two leaves and a seed from the Fijis, that the native country of any species was known. In 1891 the Rev. R. B. Comins brought seeds of two apparently distinct species from the Solomon Islands, and the following year he succeeded in obtaining a specimen of one almost past the flowering stage, and a ripe fruit. The latter resembles a pear of medium size, and contains a single compressed seed with an exceeding hard testa, smooth and shining on what may be termed the dorsal surface, which extends into an overlapping, more or less jagged or spiny, margin, and a more or less uneven and spiny ventral surface. The

[1] *The Solomon Islands and their Natives*, H. B. Guppy, 1887, pp. 280-307.

[2] W. Botting Hemsley, in *Annals of Botany*, v., 1891, t. 27.

[3] To be published shortly by the writer, with some other novelties from the same region, in the *Journ. Linn. Soc.*, vol. xxx.

[4] W. Botting Hemsley, in *Annals of Botany*, vi., 1892, pp. 203-210, plates 11-14.

Solomon Islanders are well acquainted with the seeds, from which they extract the embryo, and use the hard shell for various purposes. From their resemblance, the natives call them turtle-seeds; and they sometimes engrave figures of a not inelegant pattern on the dorsal surface. Four species are imperfectly known: one from Fiji, two from the Solomon Islands, and one of which the native country is unknown. A seed of one of the Solomon Islands species was sent from Edinburgh for identification, and this was labelled as having been received from the New Hebrides. More complete material is wanted of all the species, and for this reason these somewhat full particulars are given.

Rarity of Australian types is almost equally as marked in the Solomon Islands as in Eastern Polynesia—an undescribed *Grevillea* and *Dendrobium hispidum* are exceptions. Of course, more complete explorations may reveal closer affinities. The Germans have collected considerably in the northern islands of the Solomon group, in the islands composing the Archipelago of New Britannia, better known, perhaps, as New Britain and New Ireland, as well as in the Caroline and Marshall Islands, in the North-West Pacific; and these collections have been published by various botanists.[1] The novelties described are chiefly specific, and belong to characteristic Malayan genera. *Hansemannia* is a proposed new pluricarpellary genus of the Mimoseæ; but, as Bentham long ago suggested,[2] it would be better, perhaps, to treat these pluricarpellary Mimoseæ as species of the genera to which they are otherwise very closely allied, rather than as independent genera. Taken altogether, these contri-

[1] Ueber den Vegetationscharacter der Inseln der Neubritannischen Archipels und der Insel Bougainville: Naumann, in Engler's *Jahrbucher*, vi., 1885, pp. 422-426. Die auf der Expedition S. M. S. "Gazelle" Gesammelten Orchideen: Kränzlin, in *op. cit.*, vii., 1886, pp. 435-443. Die auf der Expedition, etc., Gesammelten Phanerogamen: Engler, *op. cit.*, pp. 444-480. Die flora der deutschen ostasiatischen Schutzgebietes: Schumann, in *op. cit.*, ix., 1887, pp. 189-223. Flora des Stewart-Atolls im Stillen Ocean: Günther Ritter von Beck, in *Ann. des K. K. Naturhist, Hofmus*, iii., 1888, pp. 251-256.

[2] *Transactions of the Linnean Society*, xxx., p. 349.

butions to the botany of the Western Pacific can only be considered as mere fragments; but, so far as they go, they indicate greater peculiarity in the Solomon Islands than in the other groups. Sir Ferdinand Mueller has also published many contributions to the flora of Western Polynesia, especially of the New Hebrides, Loyalty and Samoan groups; but they are so scattered that it would be a great labour to attempt to give an idea of what they embrace. One specially interesting addition is *Eucalyptus Naudiniana*, from New Britain,[1] an extreme outlier of the great Australian forest element.

Stewart Atoll consists of several islands, in about 8° 22′ S. lat., and may be considered as an outlier of the Solomon group. The Austrian *Novara* expedition landed for a few hours only on Faule or Small Island, where about a dozen and a half different plants were collected, including *Fimbristylis faulensis*, *Fleurya glaberrima*, *Procris obovata*, *Schmidelia lasiostemon* and *Bassia microcalyx*, described as new. Although this island is only from eight to ten feet above the mean level of the sea, and only one nautical mile in circumference, it was found to be covered with a luxuriant vegetation of trees and shrubs; the trees in the centre of the island being of large dimensions. It is also stated that the American mangrove, *Rhizophora mangle*, has established itself, and grows most luxuriant on the lagoon side of the island. This, if not an error, is exceedingly interesting, as Mr. J. J. Lister collected a specimen of this species in the Tonga Islands. and we could only suppose that it had been accidentally introduced with ballast, because we could find neither specimens nor record of any from any other locality westward of America; the common species of Eastern Polynesia and the Malay Archipelago being *R. mucronata*.

Among the islands of the North-West Pacific recently botanically explored are the Bonin group, and Sulphur Island, situated a little to the south-west of Bonin. Also

[1] *Australian Journal of Pharmacy*, July, 1886.

the essentially Asiatic Luchu Archipelago, to the south of Japan, and the Kurile chain in the north, connecting Yesso with Kamtschatka.[1] The list of vascular plants collected in Sulphur Island numbers twenty-seven, including five ferns and one epiphytic orchid, *Luisia teres.* Several of the plants are identified with Japanese species, and, with one exception, the rest are common littoral plants of the Pacific, or of wider range. The exception is *Dodonæa Thunbergiana.* Eckl. and Zeyh., a native of South Africa and Bourbon Island. We suspect that it may be a narrow-leaved variety of the ubiquitous tropical *D. viscosa*, rather than this comparatively local species.

Ceylon is so near the mainland of India, with which it is almost connected by stepping-stones, that its flora can hardly be termed insular in the generally accepted sense of the word; yet, for many reasons, it claims a mention here, and more particularly on account of the important recent literature.[2] Ceylon is so well situated, so easy of access, its flora so rich, its climate so good, and its botanic garden so well adapted for scientific work, that it is to be hoped that the laboratory which has been

[1] "On the Plants of Sulphur Island," Samuro Okubo, in the *Journal of the College of Science*, Imperial University of Japan, ii., 1888, pp. 143-147. "Die Liukiu Inseln," O. Warburg, in the *Mittheilungen der Geographischen Gesellschaft in Hamburg*, 1890, reprint, pp. 25. "The Flora of the Kurile Islands," Kingo Miyabe, in *Memoirs of the Boston Society of Natural History*, iv., 1890, pp. 203-275, with a map. "Eine Reise nach den Bonin und Volcano-Inselm," O. Warburg, in the *Verhandlungen der Gesellschaft für Erdkunde zu Berlin*, 1891, reprint, pp. 21, with a map.

[2] "Notes on the Flora of Ceylon," H. Trimen, in the *Journal of Botany*, 1885. "A Systematic Catalogue of the Flowering Plants and Ferns Indigenous to, or Growing Wild in, Ceylon," H. Trimen, 1885. "Remarks on the Composition, Geographical Affinities, and Origin of the Ceylon Flora," H. Trimen, in the *Journal of the Royal Asiatic Society*, Ceylon Branch, xi. (1885). "On the Flora of Ceylon, especially as affected by Climate," H. Trimen, in the *Journal of Botany*, 1886. "Additions to the Flora of Ceylon," H. Trimen, in the *Journal of Botany*, 1889. "Handbook of the Flora of Ceylon," H. Trimen, part i., 8vo, pp. 327, with 25 plates, 1893.

established there may be more frequently visited by botanists, who will thus enjoy the opportunity of studying vegetable biology under the most favourable conditions. Trimen estimates the indigenous phanerogamic flora at 2729 species, after deducting about 200 aliens which are more or less thoroughly colonised. This computation, it should be mentioned, is based on a very broad view of species, and when we take into consideration that Ceylon is about one-sixth smaller than Ireland, and has no really alpine flora, this number is really high, even for a tropical region. It may be mentioned in this connection that the greatest concentration of species in small areas occurs in temperate regions of the southern hemisphere, in West Australia, and South Africa. Nearly thirty per cent. or about 800 species are endemic in Ceylon ; but the number of peculiar genera is smaller than might have been expected, being only about twenty, or something like two per cent. One of the most important facts brought to light by Dr. Trimen's analysis of the composition of the flora is the much stronger Malayan affinities than those exhibited by the flora of the Indian peninsula. Upwards of one hundred Ceylon genera are not represented in the Indian peninsula, and, deducting the twenty endemic ones, there still remains the remarkable fact that eighty-seven genera of wider distribution are represented in Ceylon, but not in the Indian peninsula. Of these, fifty-six are represented by endemic species, and thirty-one by non-endemic species.

The botany of what may be termed the Indian Islands has been very assiduously investigated by Dr. Prain, who has published a considerable number of papers on the subject.[1] Primarily, the Laccadives attract our attention. They are wholly coral, and form a chain of peaks some

[1] "A List of Laccadive Plants," David Prain, in the *Scientific Memoirs by Medical Officers of the Army of India*, part v., 1890, pp. 47-69. "The Non-indigenous Species of the Andaman Flora," D. Prain, in the *Journal of the Asiatic Society of Bengal*, lix., 1890, pp. 235-261. "A List of Diamond Island Plants," D. Prain, in *op. cit.*, 1891, pp. 271-294.

6600 feet above the bottom of the sea, but nowhere rising more than twenty feet above the level of the sea; and they are only 120 to 180 miles distant from the mainland of India. Storm-waves have from time to time swept away half the population; yet many of the islands are still inhabited, and they have a "human history" of over 500 years. As to the vegetation, Dr. Prain enumerates eighty species of vascular plants, including only two ferns, more than half of which have probably been intentionally introduced by man; many others accidentally, and only a small remainder reached the islands independently of man. Dr. Prain concludes his very careful analysis of the flora with some speculations on the probable origin of its elements in the islands; and he suggests that fifty-six species were introduced by man, eleven by the sea, two by birds, and two by winds. With regard to the coco-nut palm, he is of opinion that the evidence, both intrinsic and extrinsic, indicates that its appearance in the Archipelago preceded that of man. Without knowing what evidence he relies on for this statement, it would be bold to reject his theory; but if it can be satisfactorily established it would afford an interesting link in the history of this tree. We must dismiss this part of our subject with a brief reference to the elaborate description and tabulation[1] of the components of the vegetation of the Coco group—a group lying immediately to the north of the Andamans. The total number of species enumerated, including a few cellular cryptogams, is three hundred and fifty-eight, whereof seventy are set down as cosmopolitan in the tropics; ten others are nearly so; forty-nine are more or less widely spread throughout the tropics of the Old World; forty-one extend from South-Eastern Asia to Australasia; while one hundred and eighty-eight species are confined to South-Eastern Asia. The species are distributed among two

[1] "The Vegetation of the Coco Group," D. Prain, in the *Journal of the Asiatic Society of Bengal*, lx., 1891, pp. 283-406. "On a Botanical Visit to Little Andaman and the Nicobars," D. Prain, in the *Proceedings of the Asiatic Society of Bengal*, 1891, pp. 156-175.

hundred and sixty-eight genera and ninety-five natural orders. Thirty-two species are only known in the Andamans elsewhere, and thirteen are apparently confined to the Coco group, but some of these may yet be found to have a wider range. In any case the endemic element is small and exhibits no special features. *Cocos nucifera* is abundant in all the islands, yet the author of the paper from which we are citing is of the opinion that it is not indigenous, and he is inclined to believe that its presence is due to the wreck of some coco-nut-laden craft on their coasts.

Among the smaller islands of the Indian Ocean botanically investigated within the last decade we may name Diego Garcia in the Chagos Archipelago, Krakatoa in the Sunda Straits, and Christmas and Keeling Islands off the western coast of Java.[1] In the early accounts of Diego Garcia, mention is made of gigantic trees; and if such ever existed, which is not improbable, they were probably *Afzelia bijuga* and *Cordia subcordata.* When the island was botanised in 1885, however, only a few small straggling trees were left. Forty-three probably indigenous species of vascular plants are recorded from the islands, and nearly all of them are common in Malaya and Polynesia. Not one of these is endemic; but two or three cellular cryptogams are described as new.

The new flora of Krakatoa[2] is one of the most instructive lessons in the distribution of plants that actual observation has ever furnished; and Dr. Treub understood how to describe it in a highly attractive form. It is to be hoped that he has been able, or will be able, to follow up his investigations begun in 1886, three years after the great catastrophe, which so utterly destroyed the previously existing vegetation, as Dr. Treub assures us, that no living vegetable was left on the ground or in the ground, for so

[1] "Report on the Botany of Diego Garcia," W. Botting Hemsley, in the *Journal of the Linnean Society*, xxii., 1886, pp. 332-340.

[2] "Notice sur la Nouvelle Flore de Krakatau," Treub, in *Annales du Jardin Botanique de Buitenzorg*, vii., 1888, pp. 213-223.

much of the island as was left after the great volcanic eruption was covered with ash of such intense heat as to destroy absolutely all vegetable life. The substance of Dr. Treub's paper has already been given in English;[1] therefore it will be sufficient to mention the leading facts. We have it on good authority that the whole island was covered with a layer of burning pumice-stone, ranging from one metre to sixty metres in thickness. Further, at the time of Dr. Treub's visit, there was no possibility of the new flora being in any part the result of human agency; and the composition of the new flora was such as to preclude the possibility of its being derived either from the former flora of the island, or from direct or indirect introductions by man. Dr. Treub traces the new vegetation from a thin film of various species of *Lyngbya* and other *Cynophyceæ*, acting chemically on the pumice-stone and preparing it for a fern vegetation, partially succeeded at that date already by a number of flowering plants. About a dozen species of ferns had established themselves, and some of them were abundant, whereas the flowering plants were limited to a few scattered individuals. The seeds of various common littoral plants were observed on the shore, and a few young plants of *Erythonia* sp., *Calophyllum Inophyllum*, *Cerbera Odollam*, *Hernandia sonora*, *Ipomœa biloba*, and two or three others, all of which, doubtless, owed their presence mainly to the action of the waves. The few plants found on the mountainous interior were, with the exception of one grass, *Gymnathrix elegans* and *Scævola Kœnigii*, of different species, the seeds of which were conveyed by wind or birds. Four out of eight were composites, two grasses, and the other two *Scævola Kœnigii* and *Tournefortia argentea*. It may be added that the island is distant ten, twenty, and twenty-one geographical miles from the islands of Sibesie, Sumatra and Java respectively, the nearest points on which there was vegetation.

[1] "The New Vegetation of Krakatoa," W. B. Hemsley, *Nature*, xxxviii., 1888, p. 344.

Christmas Island[1] is situated about 200 miles off the west coast of Java, from which it is separated by a sea bottom some 14,500 feet deep. It is about twelve miles across in its greatest diameter; rises to an altitude of 1200 feet, and is covered with a luxuriant vegetation, including lofty buttressed trees of colossal size. The total number of species collected by Mr. Lister, and the officers of H.M.S. *Egeria*, consisted of fifty-five phanerogams, seventeen vascular, and eight cellular cryptogams; but it is probable that a thorough botanical exploration would yield more than double the number of vascular plants, to say nothing of cellular cryptogams. Several species are described as new, but until the flora of Java and the neighbouring islands is better known, it would be hazardous to assume that they are really endemic. The supposed novelties include two ferns, two orchids, and a palm—*Arenga Listeri*.

Passing to the Keeling or Cocos Islands, some five hundred miles westward in the open sea, we meet with a very different flora—the flora of low coral islands. This is classic ground; for it was here, in 1836, that Darwin collected many facts afterwards utilised in his great works. He was followed by H. O. Forbes in 1878, and H. B. Guppy in 1888.[2] The latter gentleman spent ten weeks in the islands, and succeeded in adding considerably to what was previously known of that element of the vegetation which it is believed reached the islands without the direct or indirect aid of man. Moreover, he critically examined the vegetable drift, which is often cast ashore on these islands in great abundance, in relation to the germination of the seeds contained therein and the colonisation of

[1] "Report on the Botanical Collections from Christmas Island," W. Botting Hemsley, in the *Journal of the Linnean Society*, xxv., 1890, pp. 351-362.

[2] "The Dispersal of Plants, as Illustrated by the Flora of the Keeling or Cocos Islands," a paper read at the Victoria Institute, H. B. Guppy, Feb. 3, 1890. *N.B.*—This paper was not published, but the writer of the present article was permitted to use it, and he gave the substance of it in *Nature*, xli., pp. 491-492.

plants by this means. In this way he collected a number of most interesting facts, which he supplemented by experiments on the spot with seeds that he kept in sea-water for thirty, forty or fifty days; many of which germinated freely. He observed large numbers of drift-seeds sprouting; but few of these escaped destruction by crabs. He also brought away a large number of seeds, with which he has since experimented, and made the results known to the writer. We may give one example: Seeds of *Ipomœa grandiflora* collected in the Keeling Islands in September, 1888, were kept dry until June, 1890, and then placed in sea-water until June, 1891, when they were subjected to conditions favourable to germination, which followed with vigorous after-growth. One plant thus reared is still growing at Kew. From time to time Mr. Guppy has sent the writer various germinating seeds that had been subjected to similar conditions. Experiments with, and observations on, the germination of the coco-nut, go to prove that it can rarely establish itself from drift-seeds, especially where there are crabs. And it should be mentioned that the instance recorded[1] of a growing coco-nut on the recently upheaved Falcon Island, in the Tonga group, was not, as was at first supposed, the result of accident; for it has since been ascertained that a chieftain of one of the neighbouring islands actually planted the seeds.

W. Botting Hemsley.

[1] W. Botting Hemsley, in *Nature*, xli., p. 537.

# FOSSIL PLANTS.

DURING the last two or three decades, the study of fossil plants has been gradually tending towards the point at which its importance is acknowledged by botanists and geologists. Even now there are many botanists who have little faith in the possibilities of palæobotany as an aid to the elucidation of important botanical problems; and among geologists it is the rule to attach extremely little weight to the evidence of fossil plants in stratigraphical questions. This scant recognition of the value of such a science is easily understood if we consider the nature of the materials with which a palæobotanist has to deal. The field geologist is familiar with the forms in which plant fragments most commonly occur in stratified deposits, and, at the same time, he is aware of the rashness not infrequently displayed in the determination of species from the most imperfect data.

It is true that fossil plants cannot compare with fossil animals as indices of geologic age in the majority of cases; this is partly because the sedimentary strata of the earth's crust are usually richer in marine than land organisms, and in part because the skeletons of animals are obviously more likely to occur as useful records than the imperfect fragments of land vegetation. There are those strata, however, in which the fossils are largely or almost entirely of a plant nature. In the hands of specialists such fossils may be used with a considerable measure of success in comparative stratigraphy.

No one has displayed a greater zeal in combating the practice of building up specific diagnoses on the merest fragments of badly preserved plants than Prof. Williamson. We recognise the worthlessness of many such determinations, and appreciate the dangers frequently involved in assigning generic and specific names to fossil plants; but we can still point to striking instances of the utility of such

fossils in cases where conclusions have been drawn from the general facies of a flora, and not from a few fragmentary relics of individual forms.

Recent monographs on the geologic floras of special districts, especially of Carboniferous or Permo-Carboniferous age, afford the working geologist valuable, and in the main reliable, guides in his study of comparative geology. We cannot help thinking that the time has come for a much wider application of the teaching of fossil botany, especially in such problems of stratigraphy where plant remains constitute by far the most abundant material at the disposal of the geologist; and in cases where zoology and botany contribute almost equally to the fossil contents of rocks, the botanical specimens may be used with considerable advantage as confirmatory or even corrective evidence by the side of fossil animals.

Botanists have long hinted that palæontological study ought to throw light on general questions of morphology, but until recent times they have seldom made any serious attempt to bring under contribution the contents of plant-bearing strata. It is only within the last few years that fossil botany has come to be regarded by working botanists as a subject to which it would not be altogether hopeless to turn for definite information and helpful suggestion. No doubt the publication in 1887 of Count Solms-Laubach's *Einleitung in die Paläophytologie* gave a stimulus to those who wished to extend their observations beyond the limits of the present age. At the same time, this comprehensive treatise formed a much needed guide in giving some kind of order to the great mass of isolated contributions to fossil botany, and, by its cautious criticisms of conflicting views, it has enabled the botanist to approach with more confidence a department of his subject which he has hitherto almost ignored.

Since the days when microscopy was first applied to the minute study of fossil plants, material has been gradually accumulated, and dealt with in such a manner that at length the vital importance of the study has been more widely recognised, and the surprisingly perfect state of

preservation of many of the extinct plants has become more generally known and appreciated. If we turn to the numerous memoirs by Prof. Williamson, "On the Organisation of the Fossil Plants of the Coal-Measures," which have appeared in the *Philosophical Transactions* from 1871 to the present time, we find there a wonderful wealth of material which has steadily increased, and from the investigation of which many of the lacunæ in the necessarily imperfect records of palæozoic botany have been gradually filled in.

Already the stage has been reached at which it is possible to gather up the descriptions of isolated specimens, and to obtain from them a surprisingly complete picture of several types of extinct plants. Unfortunately it is too much to expect that we can ever be in possession of the complete life-histories of these extinct forms; it is almost hopeless to look for information as to the earliest stages of development of such ancestral types. Still we venture to think it is not too much to expect, that the almost perfect state of preservation in which palæozoic plants are occasionally found may yield something more than negative results even in questions of development.

In the contributions to this journal dealing with fossil botany, it will be the object of the writer to attempt a periodic survey of some of the more important and most recent contributions to palæobotanical knowledge which may prove useful to botanists and geologists.

Those publications which are spoken of in the present notice have appeared during the year 1893, and for the most part during the latter half of the year; but it has been thought better, in this first article, not to confine our retrospect within the strict limits of the last six months of 1893, but to draw attention to such recent works as have materially contributed to the progress of the science. At the end of each article there will be appended a list of most of those contributions to fossil botany which have appeared during the interval between each review of recent literature. Geological succession, rather than botanical affinity or authorship, will, as far as possible,

determine the order of treatment of the matter passed in review.

Any additions to our knowledge of the floras of pre-coal-measure times are especially valuable: their value is increased by the fact that we are still very ignorant of the true nature of the vegetation anterior to the Upper Carboniferous period, and also because of the great importance of extending our retrospect as far back as possible towards the earliest phases of plant evolution.

The list of undoubted fossil plants from strata older than the Devonian period is an exceedingly small one. In the case of the earliest records of plant fossils there are always certain forms which are of no botanical value, and which have little or no claim to occupy a place in the vegetable kingdom.

Since 1878, the genus *Glyptodendron* of Claypole[1] has frequently been quoted as a Silurian plant, resembling a *Lepidodendron* in its surface markings. Now it appears we may consider Claypole's genus as in all probability a fragment of a Silurian Cephalopod, and not a plant. This conclusion has been arrived at by Mr. Foerste[2] after a thorough examination of the type specimen, and a comparison of it with some Cephalopods from the Clinton limestone which have certain surface markings apparently identical with the "scars" of *Glyptodendron*. Strong confirmation of these views is expressed in a footnote by Claypole, who considers that Foerste has made out a good case against the existence of fossil plants of Clinton age in Ohio.

In recent years the microscopic examination of sedimentary rocks has been to a certain extent revived, and some of the results obtained are of great interest with regard to the part played by vegetable organisms in the process of rock-building. Mr. Wethered's researches have

[1] *Geol. Mag.*, Dec., ii., vol. v., 1878, p. 558.

[2] *American Geologist*, vol. xii., 1893, p. 133. Mr. A. H. Foord tells me that the *Glyptodendron*-like pattern represented by Foerste on the *Crytoceras* must be some encrusting foreign matter, and not a part of the Cephalopod shell.

done much to direct attention to the existence of the problematic *Girvanella* in many British limestones. In his most recent communication[1] on this subject the author speaks of the discovery of new and interesting forms of this alga (?), and of its share in the composition of the Wenlock limestone. Mr. Wethered's paper should be consulted for a fuller account of *Girvanella*, and for references to other papers treating of this widespread fossil.[2]

Passing on to the Devonian period, we may briefly notice two contributions from Prof. Penhallow on certain plants from Canada. In the first of these[3] he gives brief descriptions and photographic reproductions of a number of plant fragments, which, in themselves of no particular botanical interest, are worthy of record as characteristic fossil plants which may possibly be assigned to the class *Algæ*. The specimens described are in the form of structureless carbonaceous impressions, and as such are by no means perfect. The author of the paper has followed previous writers in giving expression to a resemblance in form, detected in the fossil species, to the vegetative parts of recent algal genera, by adopting such names as *Haliserites* and *Dictyotites;* it would probably be better, certainly much safer, to adopt some less committal genus indicative of algal affinities, and not such names as are based on mere external resemblances of vegetative structures.

The second contribution[4] deals with the problematical genus *Nematophycus;* some figures are given of microscopic sections which clearly demonstrate a much less perfect state of preservation than we are familiar with in previously described specimens of this genus. Penhallow's opinion, that Dawson's genus *Celluloxylon*[5] should be included in Carruthers' *Nematophycus*, receives confirmatory evidence; he brings forward proof that in certain cases the structure

[1] *Quart. Journ. Geol. Soc.*, vol. xlix., 1893, p. 236.

[2] *Ibid.*, p. 246.

[3] *Proc. U.S. Nat. Museum*, vol. xvi., 1893, p. 105.

[4] *Ibid.*, p. 115.

[5] *Quart. Journ. Geol. Soc.*, vol. xxxvii., 1881, p. 302.

of *Nematophycus* has been replaced in the process of mineralisation by a typical *Celluloxylon* structure.

In 1850, Goeppert described a plant stem from the Carboniferous limestone of Falkenberg, in Silesia, under the name of *Protopitys Buchiana*.[1] A recent number of the *Botanische Zeitung* contains a paper by Solms-Laubach[2] in which a clear case is made out for the removal of Goeppert's plant from the *Coniferæ*, in which it was originally placed, to the *Pteridophyta*. Most of the fragments of *Protopitys* which have their minute structure preserved are small pieces of secondary wood; by the examination of these and some few more complete examples, Count Solms has been able to demonstrate the following anatomical details. The secondary xylem shows the general character of coniferous wood; regularly disposed rows of polygonal pitted tracheids, with fairly numerous medullary rays generally one cell and sometimes two or three cells deep. The pits in the tracheid walls suggest a form intermediate between the usual bordered pits of conifers and the scalariform pits of fern tracheids. The secondary wood on careful microscopic examination shows no indication of annual rings. As frequently happens in fossil plants, the transverse section of a stem shows distinct concentric lines suggestive of ordinary rings of growth, but these on higher magnification are found to be simply the expressions of disturbances in the elements of the xylem.

In the pith some very interesting features are recorded; instead of the normal plan in which the primary medullary rays terminate in the cells of the pith, there is a closed central strand which is parenchymatous in the central part, and, at the periphery, is composed of irregularly arranged tracheal elements. A transverse section of the pith shows an elliptical form with two ear-shaped swellings at the ends of the major axis. The tracheal sheath surrounding the parenchymatous centre consists of one to three rows of

[1] *Monograph. Foss. Conif.*, p. 229. Pl. xxxvii., figs. 4-7. Pl. xxxviii., figs. 1, 2.

[2] *Bot. Zeitung*, Heft 12, 1893, p. 197.

elements, except at the auriculate swellings where its thickness increases. This sheath of tracheal elements occurs, therefore, between the radially arranged tracheids of the secondary xylem and the central axis of the stem; its tracheæ are distinguished from those of the secondary xylem by a scalariform pitting and larger diameter.

By an examination of a series of transverse and longitudinal sections, Solms made out that from the two ends of the major axis bundles of primary tracheæ become detached from the elliptical sheath, and pass off to supply certain lateral appendages arranged alternately in two vertical rows. The conclusion is arrived at that the appendages are of the nature of leaves, and, in the stem sections described, the scars left by the fallen leaves have been completely covered over by a development of secondary wood subsequent to the leaf-fall. The cortex is rarely preserved; the plane of the Cambium in one of the figured sections being occupied by a layer of calc-spar; externally, the Cambium is followed by alternating bands of pitted sclerenchymatous tissue and crushed thin-walled elements, probably representing bands of hard and soft bast; the thick-walled cells are, however, isodiametric and not fibrous in form.

In speaking of the affinities of this plant the author of the paper naturally lays stress on the primary tracheal sheath as a character which at once separates *Protopitys* from Gymnosperms and *Calamarieæ;* on the other hand, it shows a resemblance to such plants as *Sigillaria* and *Lyginodendron*, especially *Lyginodendron Oldhamium* Will. The differences between *Protopitys Buchiana Goepp.* and *Lyginodendron Oldhamium* are sufficiently numerous to warrant the institution of a new family, the *Protopityeæ*. The sole representative genus affords another example of a synthetic type of plant in which there appear characters intermediate between the *Filicineæ* and Gymnosperms, indicating the descent of these two classes of plants from an original ancestral group.

Passing to Upper Carboniferous times there are several contributions to be noticed of exceptional interest.

In the first place, with regard to the genus *Lepidodendron.* The last memoir by Prof. Williamson[1] enables us to fill in various gaps in our knowledge concerning the connection between certain external features and internal structure in species of *Lepidodendreæ.*

The well-known species *Lepidodendron Harcourtii Brong.* represents a particular form of the genus in which, as yet, no traces have been found of a development of secondary xylem, such as characterises the central stele of other examples of *Lepidodendron.* Williamson's latest contributions to our knowledge of this species are chiefly concerned with the outermost cortical tissues, the leaves and leaf-traces. The leaf-traces arise as groups of tracheal elements which become detached from regularly placed projections on the outer side of the primary tracheal cylinder ("corona" of Bertrand); each trace is double, and consists of a small group of tracheids with hard and soft bast, of which the former is frequently preserved; the bundles were probably of the collateral type. As each leaf-trace reaches the outer part ("prosenchymatous zone") of the cortex of the stem a new structure becomes closely associated with it: a tangential section of a trace at this stage of its course towards a leaf shows, immediately above the tracheids, a group of fairly large and irregularly arranged cells, constituting a well-marked structure, to which Bertrand has assigned the name "parichnos".

As the leaf-trace continues its course towards a leaf the parichnos divides into two halves, which become slightly separated laterally from the vascular element of the leaf-trace, and finally appear in the surface view of a leaf-scar as two dots placed one on either side of the central vascular bundle scar.

In a well-preserved *Lepidodendron* stem it is easy to see the three characteristic marks on a leaf-scar; the central dot has for some time been referred to the leaf-trace, but the nature of the lateral dots has remained a puzzle until quite recently, and even now it is impossible to

[1] *Phil. Trans.*, vol. clxxxiv., 1893, B, p. 1.

definitely determine the physiological significance of the parichnos tissue.

These two parichnos scars occur both on the ordinary form of *Lepidodendron* and *Sigillaria* leaf-scar, as well as in the leaf-scar of *Lepidophloios*. In the latter genus, Potonié[1] has recently described the same structures; he compares them to mucilage canals in the leaves of some *Lycopodia*, and, more especially, to "transpiration strands," analogous to the tissue at the base of some fern leaf-stalks, which is visible at the surface as lentical dots.

In a *Lepidodendron* leaf-cushion there are occasionally seen, immediately below the leaf-scar, two small elliptical areas, the real nature of which has not been previously recognised. Potonié shows by a longitudinal section of a leaf-cushion of *Lepidophloios* how the parichnos tissue passes from the leaf-scar into the fundamental tissue of the cushion, and in the latter follows a course just below the epidermal tissue; for a short distance the epidermal cells of the leaf-cushion appear to be partially or completely disorganised, thus leaving the parichnos tissue exposed at the surface. This surface view of the two branches of the parichnos is represented on the surface of a leaf-base by the two elliptical marks below the leaf-scar. With regard to the *Lepidophloios* form of leaf-cushion, there has been much difference of opinion as to whether the leaf-scar represents the lower or upper surface of the leaf-cushion. Williamson and others consider that the scar should be regarded as the upper end; Potonié, on the other hand, places it at the lower end, and brings forward certain facts in support of his view which seem to be of considerable weight.[2] In addition to the markings already mentioned

[1] *Ber. deutsch. bot. Ges*, Jahrg. ii., Heft 5, 1893, p. 319.

[2] The specimen figured by Potonié was originally described by Weiss as an unusually large strobilus (Solms-Laubach, *Fossil Botany*, p. 235). In 1890 (*Proc. Camb. Phil. Soc.*, vol. vii., pt. ii., p. 3) I published a note, with rough sketches, in which the real nature of the Berlin specimen was pointed out. Potonié, in confirming my opinion, maintains—and, I believe, rightly—that my fig. 4 represents the leaf-cushions and scars wrong side uppermost (*Zeitsch. deutsch. Geol. Ges.*, Protokoll, Mai, 1893).

on the Lepidodendroid leaf-cushion, there is frequently a triangular depression immediately above the upper limit of the leaf-scar; this has been regarded by some as the position occupied by a ligule, but Williamson does not accept this view, and prefers to speak of the structure which appears at the surface of the cushion in the form of triangular depression as the "adenoid organ".[1] It is well shown in some of Williamson's figures of *Lepidodendron Harcourtii* leaves; and Potonié also figures and describes the same structure, and accepts the suggestion of its ligular nature.[2]

Another important question on which light is thrown by Williamson's memoir is the connection between *Halonia* and *Ulodendron;* Brongniart's original distinction between the two genera, based on the numerous rows of quincuncially arranged tubercles in the former, and the two vertical rows of the latter, is shown to be no longer tenable. In both genera the tubercles are evidently of the same nature, and represent the points of attachment of strobili. In some forms of Lepidodendroid stems the strobili were sessile,[3] in others they terminated longer or shorter leafy axes;[4] in the former case, the base of the strobilus would press against the surface of the stem, and produce a pressure disc such as we are familiar with in typical Ulodendron specimens. If the strobili were not adpressed to the stem, there would be no pressure disc formed, and the result would be the Halonial form of branch.

Williamson's excellent figures and descriptions should be consulted for a fuller account of this interesting question.

Another communication from Potonié[5] deals with the

[1] *Phil. Trans., loc. cit.*, p. 12.

[2] Since this was written, Prof. Williamson has told me that the figures of Lepidodendroid leaf-cushions, in his recent memoir, represent the structures in an inverted position; his interpretation of the facts agrees, therefore, with that of Potonié and others.

[3] *Phil. Trans, loc. cit.*, pl. vi., fig. 26 a.

[4] *Ibid.*, pl. v., fig. 27 a.

[5] *Ber. deutsch. bot. Ges.*, Jahrg. ii., Heft 8, 1893, p. 484.

nature of Halonia, but unfortunately the author had not seen the last contribution on the same subject by Prof. Williamson.

After speaking of the various suggestions as to the nature of Halonial axes, Potonié expresses his belief that such structures only occur in connection with *Lepidophloios*, and not with *Lepidodendron* stems: he suggests the advisability of re-examining the specimen in the Leeds Museum which Williamson figured in 1883,[1] as proving the organic continuity of *Halonia* and *Lepidodendron*. Another addition to previously incomplete knowledge is made by Williamson with regard to a curious form of *Lepidostrobus*,[2] belonging to that type of vegetative axis named by him in 1889,[3] *Lepidodendron Spenceri*. It is shown that we have in this plant not only a well-defined form of stem structure, but also an equally well-marked type of strobilus characterised by its winged spores and other peculiarities of structures.

We are indebted to Prof. Bower[4] for an exceedingly interesting account of a species of *Lepidostrobus*,—*L. Brownii* Schmp. preserved in the British Museum, and known as "Brown's Cone"; he gives a detailed description of the axial structures, and dwells at length on certain features characterising the well-defined cortical tissues. The general structure of the stele of *L. Brownii* seems to agree fairly closely with *Lepidodendron Williamsoni*.[5] Occupying the centre of the strobilus axis is a parenchymatous pith with a ring of primary xylem giving off leaf-traces from its outer crenulated margin. Surrounding this cylinder of tracheids Bower describes a somewhat meagre development of phloem, and draws attention to certain cells enclosing the whole stele which exhibit

[1] *Phil. Trans.*, 1883, pt. ii., pl. xxxiv.

[2] *Ibid.*, 1893, B, p. 24.

[3] *Ibid.*, vol. clxxx., 1889, B, p. 199.

[4] *Annals Bot.*, vol. vii., 1893, p. 329.

[5] Solms-Laubach, *Fossil Botany*, p. 226.

structural details suggestive of an endodermis.[1] The leaf-traces, probably collateral in form, are followed in their course from the xylem cylinder to the outer cortex; and it is shown how the tissues composing the inner cortical zone become gradually more lax towards the periphery, and finally give place to a wide space in which the leaf-traces appear as isolated groups of tissue. The cells of the inner cortex surrounding each trace become elongated, and gradually separate from one another in the form of trabeculæ as we pass to the more loosely arranged part of the cortex. In the middle cortex the bundles appear to be surrounded by a few layers of parenchymatous cells, and have the form of isolated strands, in consequence of the formation of a wide space in the middle zone of the cortex. Towards the apex of the strobilus, the median cortical space becomes narrower and bridged across by trabeculæ, which stretch from the outer and inner tissues of the cortex to the several leaf-trace bundles. Bower's figures show a very striking resemblance between the central stele of *Psilotum* and that of *Lepidostrobus Brownii;* the parenchyma of the pith in the fossil specimen is more like the corresponding tissue occupying the axis of *Tmesipteris*, than the sclerenchymatous elements in the pith of *Psilotum*, thus affording "a most interesting example of cross correspondence". There is also a detailed comparison instituted between the cortex of *Lepidostrobus Brownii* and other species of *Lepidodendron* with various forms of *Lycopodium* and *Selaginella;* it is stated that the several types of structure met with among fossil forms may be "matched by similar characters in living forms of close alliance".[2] After speaking of the trabecular tissue in the cortex of extinct and recent forms, Bower adds, with reference to *Selaginella*, that "the trabecular development in *Selaginella* is a specialised and more definite example of that lacunar development which

[1] *Cf.* Hovelacque, *M. Soc. Linn. Normandie*, vol. xvii., 1892, figs. 11 and 12, pp. 50 and 52.

[2] *Annals Bot.*, vol. vii., p. 348.

appears in such various forms and positions in cortical tissues of various other Lycopodinous plants".[1]

To quote, in conclusion, one more sentence from this paper: "All these considerations serve to draw the Lycopodinous plants of the present and the past more closely together as a natural family, while it is interesting to note that the lines of similarity as regards structure, form, heterospory and details of sporangia do not focus themselves specially between any two genera, but are such as to suggest complex cross-relationship between the several representatives of this very natural series".[2]

It frequently happens that in cases where we have been able to learn a good deal from specimens showing internal structure, about the histological characters of Coal-Measure plants, we are left without any precise acquaintance with the external appearance of the plants to which the mineralised fragments belonged. From time to time, however, additional specimens are brought to light which enable the palæobotanist to arrive at a fairly complete idea, not only of the histological characters but also of the gross anatomy, of individual species. A recent communication from Prof. Zeiller of Paris affords an exceptionally interesting case in point.[3]

In 1871, Williamson published a description of a strobilus from the Lancashire Coal-Measures, to which he gave the name of *Volkmannia Dawsoni*, at the same time suggesting a probable affinity to *Asterophyllites* or *Sphenophyllum*.[4]

In 1884, the late Prof. Weiss of Berlin proposed to substitute for *Volkmannia* Binney's genus *Bowmannites*,[5] a proposal which is accepted by Williamson in his memoir of 1890.[6] Again, in 1891,[7] we have a much more complete

[1] *Annals Bot.*, *loc. cit.*, p. 349.

[2] *Loc. cit.*, p. 351.

[3] *Mém. Soc. Géol.*, France. *Pal. Mem.* ii., 1893.

[4] *Mem. Lit. Phil.*, Manchester, vol. v., series iii., 1871, p. 28.

[5] *Abh. geol. Specialkarte Preuss.*, v., p. 286.

[6] *Phil. Trans.*, vol. clxxxi., 1890, B, p. 99.

[7] *Ibid.*, vol. clxxxii., 1891, B, p. 255.

description of this strobilus by the same writer, and, following this, Zeiller[1] published a note in the *Comptes Rendus*, in which he points out the very close resemblance between certain specimens of *Sphenophyllum cuneifolium* and *Bowmannites Dawsoni*. In a short account of *Sphenophyllum* in *Nature*, 1892, Williamson agrees with Zeiller as to the probable identity of *Bowmannites* and *Sphenophyllum*.[2] Finally, in 1893, Zeiller reviews the whole case, and demonstrates by a series of exceedingly successful photographs, and his usual clearness of description, the very striking correspondence between the English specimens, with their clearly preserved structure, and the French and Belgian specimens of *Sphenophyllum* strobili. Want of space does not allow of a complete abstract of Zeiller's concise description of the histology of *Bowmannites*, as interpreted by Prof. Williamson.

In *Bowmannites Dawsoni* we have a central axis bearing verticils of bracts; the bracts of each whorl are fused together at the base in the form of a continuous "nodal disc," the free portions of the disc being prolonged obliquely upwards for two or three internodes. Between the verticils there occur numerous sporangia arranged in a multiseriate manner, in such a way that they form a series of circles arranged round the axis of the strobilus. The rings of sporangia are not concentric, but the centre of each successive circle reaches a higher level on the axis of the strobilus, the height increasing with the increase in length of the radius of each circle. The sporangia are ovoid in form, and each is supported at the tip of a slender pedicel which is given off from the upper surface of the "nodal disc"; at the point of junction of each pedicel with its sporangium, the cells of the former increase somewhat in size, and appear to constitute a group of specialised cells analogous to the annulus of fern sporangia. The spores are of one kind, and present a characteristic surface appearance due to the presence of slightly projecting and anastomosing ridges. As

[1] *Compt. Rend.*, vol. cxv., 1892, p. 141.

[2] *Nature*, vol. xlvii., p. 11.

regards the central axis of the strobilus, its structure closely corresponds to the stele of *Sphenophyllum* as described by Renault[1] and Williamson.[2]

Zeiller's figures and comparative measurements admit of no doubt as to the identity of *B. Dawsoni* and *Sphenophyllum cuneifolium* (Sternb.) *var. saxifragæfolium.* It is now generally admitted that the great variation in the form of *Sphenophyllum* leaves, from the broad wedge-shaped and multi-nerved, to the narrow and linear-lanceolate, single-nerved form, is simply a proof of the dimorphic character of some examples of the genus. As Zeiller points out, there are still some points to be cleared up with reference to the structure of the *Sphenophyllum* strobili. In 1876 Renault suggested that *Sphenophyllum* was heterosporous.[3] Zeiller has examined Renault's silicified specimens, and concludes that they furnish no trustworthy evidence on which to base such a statement.

After considering examples of those species of *Sphenophyllum* of which the strobili are known, Zeiller goes on to discuss the question of botanic affinity. There is a striking similarity between the ovoid sporangia of *Sphenophyllum*, supported on their slender pedicels, and the sporocarp of *Marsilia*, especially such a species as *M. pubescens* Tenore, in which the pedicel is adnate to the sporocarp for about half its length. In *Sphenophyllum* the pedicel is traversed by a vascular bundle, and arises from the ventral face of a bract, either in its axil or at a greater or less distance from the axis of the strobilus; in *Marsilia* the pedicel is a ventral lobe of a leaf, and is detached from the leaf-petiole either at its base or some little distance above it. In *Sphenophyllum* each pedicel bears one sporangium: in *Marsilia* each pedicel represents a foliar limb folded in two halves, in each of which are several sporangia. Possibly, then, we may regard the sporangium stalk of *Sphenophyllum* as homologous with the sporocarp stalk of *Marsilia.* The external layer of the spo-

[1] *Ann. Sci. Nat. Bot. Sér.* 5, vol. xviii., 1873, p. 5.

[2] *Phil. Trans.*, 1874, p. 41.

[3] *Ann. Sci. Nat. Bot. Sér.*, vi., p. 303.

rangium of *Sphenophyllum* appears to be continuous with the epidermis of the pedicel; this fact, as well as the development of secondary xylem in the strobilus axis, forms a connecting link with *Ophioglossaceæ*. On the whole, Zeiller inclines to consider *Sphenophyllum* as more nearly allied to *Ophioglossaceæ* than to *Hydropterideæ*.

As regards the vegetative parts of *Sphenophyllum*, there are certain characters, such as the verticillate leaves and jointed stem, in which *Equisetineæ* are suggested; in the primary xylem of the central stele, and the development of secondary xylem *Lycopodineæ* are indicated. Probably we must regard *Sphenophyllum* as belonging to a special class of Vascular Cryptogams, and one which finds its true position close to the *Filicineæ* because of the close resemblance in the fossil strobilus to the fructification of *Marsiliaceæ* and *Ophioglossaceæ*.[1]

In a summary of recent work which has contributed to the advance of palæobotany, it is important, as occasion requires, to draw attention to such records of newly-discovered plants as may be regarded as acquisitions of doubtful value. "A New Fungus from the Coal-Measures"[2] is a title which might lead us to expect some interesting addition to the scanty representatives of palæozoic Fungi. On consulting the paper with this heading, we find a plate and brief description of a specimen to which the name *Incolaria Securiformis* has been assigned; it is difficult, however, to detect any sound evidence that a new fungus has indeed been added to the flora of the Coal-Measures.

The same author, in another place, makes the startling announcement that he has discovered a Carboniferous fossil plant showing the structure of an "Endogen"; to this he gives the name *Winchellina fascina*.[3] The crude figure and curious description, so far as it is possible to form an opinion from them, indicate, as previously suggested by Knowlton,[4] a plant with some resemblance to *Psaronius*.

[1] *Mém. Soc. Géol.*, France, 1893, p. 39.

[2] *American Geologist*, vol. xi., 1893, p. 365.

[3] *Ibid.*, p. 286. [4] *Science*, vol. xxi., 1893, p. 332.

The application of fossil plants on the part of continental palæobotanists, to the sub-division and correlation of the Coal-Measures, has often been extended in the case of British strata by the work of Mr. Kidston.[1] His latest contribution in this direction deals with the Coal-Measures of Ayrshire, from which several species are described and figured, including one new species of *Lepidodendron*, *L. Landsburgii*, and a new form of *Lepidostrobus*, *L. Squarrosus*. In his remarks on a species of *Lepidophloios*, *L. Acerosus* (L. and H.),[2] Kidston adds that he has recently seen a specimen of *Lepidodendron fuliginosum* Will., which proves the *Lepidophloios* nature of Williamson's plant.

Before passing to the Permian period there is another contribution to the flora of Carboniferous times which should be mentioned, although it hardly comes within the limits of the present retrospect. In the early part of the year (1893) Mr. David White[3] published a description of a new "Tæniopteroid Fern" from the Lower Coal-Measures of Missouri, and his paper includes a suggestive discussion as to the genetic relations of such forms as *Oleandridium* (*Tæniopteris*), *Danæites*, *Megalopteris*, *Alethopteris*, etc. Such tables as the one given by White, indicating hypothetical relations, are often of considerable interest, but in most cases rest, to a large extent, on such slender evidence as sterile fragments of fronds are able to afford.

An important contribution to Permian botany has recently been made by Prof. Sterzel of Chemnitz,[4] in which he gives an elaborate account of the Rothliegende flora of the Plauenscher Grund district. Beginning with a historical sketch, and some account of fossil animals, the author goes on to deal at length with the Lower Rothliegende plants; he records the occurrence of such species as *Odontopteris obtusa* (Brong. in part) Weiss, *Callipteris prælongata* Weiss, *Pecopteris* (*Scolecopteris*) *arborescens* (Schloth.), *P. hemite-*

[1] *Trans. R. Soc. Edinburgh*, vol. xxxvii., pt. ii., 1893, p. 307.

[2] *Ibid.*, p. 343.

[3] *Bull. Geol. Soc.*, America, vol. iv., 1893, p. 119.

[4] *Abh. Math. physisch. Cl. k. Sachs. Ges. Wiss.*, vol. xix., 1893.

*loides* Brong., *P. polymorpha* (Brong.), *Dictyopteris Schützei* Roem., *P. Saronius*, *Calamites striatus* (Cotta), *C. suckowi* Brong., *C. Cisti* Brong., *Annularia stellata* (Schloth.), *Sphenophyllum oblongifolium* Germ., *Stigmaria ficoides* Brong., *Cordaites principalis* (Germ.), *Walchia piniformis* (Schloth.), several Gymnosperm seeds, etc. In addition to these species, Sterzel describes a number of new forms of ferns and other plants; in some cases, one cannot help feeling a little doubtful as to how far the institution of new specific terms has been warranted: *e.g.*, *Sphenopteris Augusti*, *S. Deichmülleri*, *Callipteris neuropteroides*, *Psaronius Dannenbergii* are all founded on very small and fragmentary specimens. In several of the ferns, information is given as to the character of their fertile pinnæ, but there is an absence of discussion so far as botanical affinity is concerned. Some important facts are recorded with reference to such forms of *Calamites* as are included under *C. cruciatus* Sterrb. (*Eucalamites* Weiss). Some figures are given of Calamitean roots in which the vascular cylinder is represented by a dark central line: it is suggested that a specimen of *Pinnularia capillacea* (L. and H.), which occurs on the surface of a *Calamites* cast, may be the root system of a Calamite, in which nothing is left but an impression of the vascular tissue. A poor specimen of *Stigmaria ficoides* is figured, but no trace of *Lepidodendron* or *Sigillaria* has been met with.

From the Middle Rothliegende *Pecopteris Geinitzii*, *P. altonis* Gutb., *Scolecopteris elegans* Zenk., *Calamites gigas* Brong., and other species are quoted: Zenker's well-known species, with its Marattiaceous fructification, is dealt with at some length.[1] The silicified fertile pinnules of this fern were originally described by Geinitz as a Myriapod, *Palæojulus dyadicus*. Finally there is a useful table of fossils, and a careful comparative account of the Rothliegende and Coal-Measure floras in which stress is laid on the importance of the two characteristic Permian plants *Callipteris* and *Walchia*.

[1] *Abh. Math. physisch. Cl. k. Sachs. Ges. Wiss.*, vol. xix., 1893, p. 124.

Before leaving the Permian period, a brief reference should be made to the recent examination of the Autun "Boghead" by Renault and Bertrand[1]; these authors published a detailed account of this carbonaceous deposit in 1892,[2] and more recently a further note on the same subject. They point to the existence of a characteristic gelatinous alga in the Autun beds, and consider that the species lived in enormous numbers in the Permian lake of Autun, and was mainly responsible for the accumulative of the boghead. To this alga they have given the name *Pila bibractensis*. In the Kerosene Shales of Australia another alga, *Reinschia Australis*, appears to have played a corresponding part, and in the Scotch "Torbanite" another species of the genus *Pila*.

In Saporta's classic work on the Jurassic flora of France[3] there are some figures of an interesting type of plant described as *Williamsonia Morieri* Sap. A well-preserved specimen has recently been examined by M. Lignier, with the result that the name *Bennettites* is substituted for *Williamsonia*. The structure closely corresponds with that of *B. Gibsonianus* Carr, recently described afresh by Count Solms.[4] Lignier[5] makes some important statements as to the morphological value of the seed-bearing peduncles, and concludes that the specimen is a gymnospermous inflorescence, which lends support to the distinctions insisted on by Solms between *Bennettitæ* and *Cycadeæ*. A further communication is promised by M. Lignier on this subject.

Mr. T. H. McBride, in a recent number of the *American Geologist*,[6] has published a photograph and brief description of a new form of Bennettites, *B. Dactensis*, from South Dakota, probably of Lower Cretaceous age.

[1] *Compt. Rend.*, vol. cxvii., 1893, p. 593.

[2] *Soc. Hist. Nat. d'Autun*, vol. v., 1892, p. 159.

[3] *Pal. Franc.* See also Saporta and Marion, *L'évolution du règne végétal*, vol. i., 1885, p. 244.

[4] *Annals Bot.*, vol. v., 1890-91, p. 419.

[5] *Compt. Rend.*, vol. cxvii., 1893, p. 867.

[6] Vol. xii., 1893, p. 248.

With regard to Tertiary and Post-tertiary fossil plants we often find that the various communications serve chiefly to add new species to the long list of fossil Angiosperms, or record fresh localities for old species. Such contributions may be of considerable interest from the point of view of plant distribution. A case in point is afforded by the conclusions arrived at by Weberbauer[1] that the genus *Brasenia*, now widely distributed in extra-European regions, was formerly a native of Europe. Weberbauer, acting on a suggestion made by Wittmack, carefully examined species of the two genera, *Holopleura* and *Cratopleura*, from the lignitic deposits of Wetteren and Biarritz, and compared them with seeds of *Brasenia*. This comparison led him to abolish the above generic names of Caspary and Weber for the recent genus *Brasenia*. The Marquis of Saporta[2] records a Tertiary species of the genus *Nelumbium* from the Aquitanian beds of Manosque, and speaks of the fossil form *N. protospeciosum* Sap., as closely resembling the Asiatic species *N. speciosum* Wild. Some interesting remarks are added on the general character of the Aquitanian vegetation in the Manosque district.

From Italy several fossil Muscineæ have been recorded by Brizi from a tufaceous deposit in the valley of the Tiber.[3] Another writer describes a new fossil Palm[4] from the Tongrien of Nuceto; the plant is named *Calamopsis Bruni* Peola, and is represented in the type specimen by a portion of a pinnate leaf with the venation clearly marked; it is compared to the living genus *Zalacca*, and appears to be the first example of Heer's genus *Calamopsis* recorded from Italy.

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[1] *Ber. deutsch. bot. Ges.*, Jahrg. ii., Heft 6, 1893, p. 366.

[2] *Compt. Rend.*, vol. cxvii., 1893, p. 607.

[3] *Bull. Soc. Bot. Ital.*, No. 7, 1893, p. 369.

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# ORIGIN AND NATURE OF CERTAIN BACTERIAL POISONS.

IT is well known that the introduction of sterilised and filtered cultures of specific pathogenic organisms into the bodies of susceptible animals is capable of either causing death or conferring immunity, according to the amount which is injected, though whether the toxic substances of the culture are identical with those that effect a chemical vaccination, is at present undecided. The nature of bacterial poisons has been extensively investigated during the last few years, and improved methods for the separation of micro-organisms from cultures, together with a knowledge of the most suitable media on which to cultivate, have considerably modified the views which were formerly held as to the chemical nature of bacterial activity.

The history of the growth of knowledge on this subject has been traced by Paschoutine,[1] and more recently by Gamaleïa.[2] The study of putrefaction by Seybert in 1758 was renewed by Gaspard, Magendie and others in the commencement of this century, while Stich,[3] in 1853, published his work on the toxic behaviour of putrefied proteids and fæcal excreta. His researches showed that the aqueous extracts of the solid excreta of an animal are poisonous when introduced into its own blood, but not when into the stomach, and, further, the excreta of one species can produce death when introduced into the bowel of another. The classical experiments of Panum[4]

[1] Paschoutine, *Cours de pathologie générale et expérimentale*, 1885.

[2] Gamaleïa, *Les poisons bactériens*, 1892.

[3] Stich, *Die acute Wirkung putrider Stoffe im Blute. Charite-Annalen*, 1853.

[4] Panum, Virchow's *Archiv*, Bd. lx., 1874. In this paper Panum draws attention to his work of 1855-56 which was published in a Danish journal, *Bibliothek for Läger*, April, 1856. Three years later this was abstracted by Busch in Schmidt's *Jahrbucher*, 1859, Heft 2, pp. 213-217.

on putrefactive poisons definitely proved that these substances were unorganised, some were soluble in water and caused symptoms of rapid poisoning ending in death, while others were soluble in alcohol and produced an effect comparable to the alkaloids of opium. Panum's work may be considered to have powerfully influenced subsequent investigations. Numerous observers confirmed and extended Panum's experiments, others isolated impure toxic substances from putrefied meat or yeast, while the first analysis of a ptomaïne obtained by the pancreatic digestion of gelatine was given by Nencki in 1876. Pathogenic cultures, artificial digestions, and the several stages of organic putrefaction yielded numerous ptomaïnes and leucomaïnes, but only when the soil on which the bacteria flourished contained proteid constituents ; further, the substances discovered by one observer differed in chemical and physiological behaviour from those found by another. These researches tended to support the view that the toxic substances produced by bacteria resulted from a specific decomposition of albuminous bodies, but all subsequent work has shown that this idea must be abandoned, and though bacterial poisons may be closely allied to proteid bodies it is certain that in the most toxic liquids they may exist in imponderable quantity ; they are difficult to isolate in a state of purity, and precise knowledge as to their physical and chemical character does not exist.

The physical properties of some toxines can perhaps be deduced from their behaviour in the processes of solution, filtration, and dialysis. Charrin and Gley[1] have separated three groups of substances, from cultures of *Bacillus anthracis* and *Bacillus pyocyaneus*, which vary in chemical, physical, and pathogenic properties.

[1] Charrin et Gley, *Archiv de Phys.*, 1891. The first group yields a precipitate with alcohol and dialyses easily. The toxic effects are proportional to the dose which produces in the rabbit, fever, intestinal hæmorrhages and albuminuria. The toxines of the second class are soluble in alcohol and do not diffuse through membranes. They produce convulsions by acting on the nervous system. The third group are volatile bodies obtained by distillation of the filtrate which diminish and even temporarily abolish the excitability of the vaso-motor system.

The study of the action of dead bacteria in the living body[1] has led to the belief that dead tubercle bacilli may themselves contain a toxine, and these bacilli, if introduced directly into a vein, produce a train of symptoms culminating in death. The autopsy shows that various organs, and especially the lungs, are permeated with minute granulations, composed of epithelioid cells, containing tubercle bacilli; the extent to which the organs are involved depends exclusively upon the quantity of dead bacilli which have been inoculated. From experiments of this nature it has been concluded that dead tubercle bacilli contain a substance which produces a necrotuberculosis characterised by lesions similar to those caused by living bacilli. A study of the histo-genesis of tuberculous processes has, however, shown that granulation-nodules, containing epithelioid and giant cells, are not specific pathological formations induced by either living or dead bacilli, but that indifferent foreign bodies can produce these changes.[2] The affection produced by dead bacilli is, therefore, not a genuine tuberculosis, but a disease in which nodules, resembling those produced by living bacilli, are disseminated through organs.

It is, however, possible that a poison or the antecedent of this may exist, as is the case with enzymes or zymogens within the cell, and this may result from the synthetic activity of protoplasm. It is well known that completely attenuated cultures form no specific toxine, though, according to Buchner[3] and his colleagues, certain proteïnes derived from the plasmatic contents of the bacterial cell pass into culture media which have supported a virulent growth. These proteïnes have the power of producing acute leucocytosis and inflammatory reaction. Proteolytic and amylolytic ferments have been

[1] Prudden and Hodenpyl, *New York Medical Journal*, 1891.
Strauss et Gamaleïa, *Archives de med. expérimentale*, 1891.
Grancher et Ledoux-Lebard, *ibid.*, 1892.

[2] Baumgarten, *Histogenese des tuberkulösen Processes*, 1885.

[3] Buchner, *Berlin. Klin. Wochenschrift*, 1890, No. 103,047, and *Centralblatt f. Chirugie*, 1890, No. 50.

proved to exist in pathogenic bacteria, and Macfadyen[1] has shown that glycerine extracts of some rapidly liquefying micro-organisms not only contain enzymes like trypsin and diastase, but that specific toxines can be obtained from the cholera spirillum and *Vibrio Metchnikovi*. By means of glycerine Löffler[2] also extracted a diphtheria toxine from cultures carried out on chopped meat, but in this case both the bacilli and the medium were the source of the poison. In connection with the question how far a micro-organism can yield a toxine as a product of its own metabolism, the recent work of Ouchinsky is of importance. Roux and Yersin[3] regard the poison of diphtheria as an enzyme, while Brieger and Fränkel[4] speak of this as a toxalbumin, but admitting at the same time that the poisons of cholera, typhoid fever, and pathogenic staphylococci are globulins. According to other investigators the diphtheria poison is an albumose or a body allied to peptone or a member of the nucleo-albumins.

Fermi[5] cultivated non-pathogenic micro-organisms on Nägeli's fluid with the addition of 1-5 per cent. of glycerine. He isolated enzymes which had an activity similar to that possessed by trypsin from cultures of *Micrococcus prodigiosus*, and *Bacillus pyocyaneus*. Guinochet[6] cultivated Löffler's diphtheria bacillus on bouillon and also on urine, and obtained a toxine by filtration. This was not very powerful, but was sufficiently so to kill guinea-pigs. Since this poison is produced in proteid-free media, he holds that the toxine cannot be looked upon as a toxalbumin, and in a later research it is shown that an accurate chemical statement about this specific toxine is not possible.

[1] *Journ. of Anat. and Phys.*, April, 1892.

[2] Löffler, *Deutsche med. Wochenschrift*, 1889, Nos. 5 and 6.

[3] Roux et Yersin, *Annales de l'Instituteit Pasteur*, 1888, 1889, 1890.

[4] Brieger and Fränkel, *Berliner Klin. Woch.*, 1890.

[5] Fermi, *Centralblatt für Physiologie*, 1891.

[6] Guinochet, *Archives de med. exp.*, vol. iv., No. 4, and *Compt. Rend.*, cxiv., No. 11.

Many pathogenic germs grow well on a fluid devised by Gamaleïa, which is wholly free from proteids, but contains glycerine, common salt, and Liebig's extract of meat.

The investigations of Ouchinsky[1] have been carried out on media which contain neither proteid nor peptone, but only well-known chemical substances. In his first communication the medium has the following composition :—

| | |
|---|---|
| Water | 1000 |
| Glycerine | 40-50 |
| Sodium chloride | 5-7 |
| Ammonium lactate | 10 |
| Calcium chloride | ·1 |
| Magnesium sulphate | ·2 |
| Biphosphate of potassium | 1 |

For some pathogenic organisms, such as Löffler's diphtheria bacillus, ·5 per cent. of urea, or ·02 per cent. of uric acid is added, and in some cases a variable amount of sugar.

On this fluid neither the bacillus tuberculosis nor Eberth's typhoid bacillus will grow, but the Spirillum of cholera and the *Vibrio avicide* (*Metchnikovi*) develop luxuriantly. Löffler's bacillus grown on the fluid without the addition of urea or uric acid yields a filtrate the toxic property of which is not very marked, 15-13 cc. being required for a lethal dose, while with the addition of urea or uric acid a filtrate is obtained 1·5 cc. of which is fatal. The cultures obviously vary in virulence, and the attenuation of this in the first case is permanent. The successive generations of a culture primarily weakened on Ouchinsky's fluid are found when grown upon ordinary glycerine bouillon to remain in this condition. The virus is absolutely attenuated and capable of remaining so in successive generations. The toxines of cholera and diphtheria examined chemically give Millon's reaction for proteid, and respond to the biuret and xanthoproteic tests. Corrosive sublimate, alcohol, lead acetate, acetic

[1] Ouchinsky, *Archives de med. exp.*, No. 3, 1893.

acid and ferrocyanide of potassium cause a precipitate, although the diphtheria toxine does not give the last reaction. On the evidence of these tests it is held that the toxines of cholera and diphtheria are proteid bodies like peptones or albumoses, and that they are synthetically produced by the micro-organisms. The latter part of this conclusion is probably correct, and is of great interest, but a far more extended chemical investigation is necessary before the proteid nature of these toxic substances can be considered proved.

In a subsequent communication[1] Ouchinsky gives the results of a renewed study of the poisons produced by the micro-organisms of typhoid, cholera, diphtheria, and tetanus, when cultivated upon a fluid of the following composition :—

| | |
|---|---|
| Water | 1000 |
| Glycerine | 30-40 |
| Sodium chloride | 5-7 |
| Calcium chloride | ·1 |
| Magnesium sulphate | ·2-2 |
| Bipotassium phosphate | 2-2·5 |
| Ammonium lactate | 6-7 |
| Sodium asparaginate | 3-4 |

The tetanus bacillus thrives on this fluid when 1-2 parts of sugar is added, and the access of oxygen is prevented by an alkaline solution of pyrogallic acid. The growth passes through the same stages as is observed in bouillon media, but the bacilli are somewhat thinner than normal. The filtered cultures show a marked toxic power; ·6-·8 ccm. sufficed to kill rabbits of a moderate weight. The poison in the filtrate is destroyed on the addition of alcohol, or when this is concentrated in a vacuum at 30°-36°, this effect being most obvious when the operation is done in daylight. The toxine of the filtrate can be obtained by precipitation with calcium phosphate, a method which was

[1] Ouchinsky, *Centralblatt f. Bacteriologie u. Parasiten-kunde*, Sept., 1893.

originally employed by Brücke for the separation of the ferments of the gastric juice. The chemical nature of the toxine, according to Ouchinsky, resembles that of an enzyme, a view supported by the earlier researches of Roux and Yersin on diphtheria, and maintained by Arloing and others.

Since tetanus bacilli do not invade the organism, but produce a toxine which passes into the system from the area of inoculation, the observations of Courmont and Doyon[1] lend support to the opinion that the toxic substances which cause tetanus result from the action in the organism of a soluble ferment produced by the bacillus of Nicolaier. These observers consider that the substance that causes spasm is a poison like strychnine, which, acting upon the extremities of sensory nerves, causes the typical contractures. But this is not the essential tetanus poison which appears to be a pathogenic ferment, since, if 3-4 cc. of the filtrate of a tetanus culture be injected either subcutaneously, or into the blood, or into muscle, a period of incubation about 24-36 hours is found to exist, and this period cannot be annulled by the injection of a hundred times the quantity; the filtrate indeed has no immediate effect. If, however, the blood of an animal with developed tetanus be transfused, the recipient at once falls into the tetanic state, which persists until the poison is eliminated. It is evident that the substance or substances in the filtrate of the bacilli have a totally different physiological effect from substances present in the blood, and further, the muscles of animals killed with tetanus filtrate yield a strychnia-poison which resists prolonged boiling, while a temperature of 65° C. destroys the poison in the filtrate. These experiments undoubtedly allow the conclusion that the substances which engender tetanus result from the action on the organism of a soluble ferment or enzyme fabricated by Nicolaier's bacillus.

The poison of tetanus is exceedingly easily destroyed. Chemical and physical agents such as a temperature of

[1] Courmont et Doyon, *Societe de Biologie*, Nos. 10 and 21, 1893.

65° C. for five minutes, direct sunlight for fifteen to eighteen hours, weak acids and alkalies destroy the activity of a tetanus filtrate, and no means of precipitating the toxine without at the same time partially or wholly removing its specific properties at present exist. Attempts to isolate the poison of tetanus have, however, been repeatedly made, and the latest work in this direction is that of Brieger and Georg Cohn.[1] Tetanus filtrates differ in virulence according to the medium on which the bacillus is grown, and a concentrated impure poison three times as powerful as the direct poison used by Kitasato was obtained from a medium of veal-bouillon containing 1 per cent. peptone and ·5 per cent. salt. The crude poison was precipitated from the sterile filtrate by saturation with ammonium sulphate. The precipitate floated on the surface, was removed, allowed to drain on porous slabs and dried in vacuo. The whole of the toxine was held in the precipitate, the remaining fluid being innocuous. Prepared in this way the crude poison contained about 6 per cent. of ammonium sulphate and other salts, proteids and peptone, amido-acids, and volatile odorous products, and its activity was neither destroyed by a temperature of 60° C. nor by the addition of absolute alcohol with 1 per cent. of corrosive sublimate. The proteid impurities were removed with basic lead acetate and a trace of ammonia, and the remainder by dialysis. Evaporation of the dialysed fluid in vacuo at 20° C. yielded the tetanus toxine in the form of faint yellow transparent scales, which are soluble in water and lævorotatory. It contains but little ash and does not respond to many of the common tests for proteids. Calcium phosphate, used with such success by Yersin and Roux in their researches on the poison of diphtheria, does not, as is the case with enzymes, remove the toxine from its solutions. The poison is free from phosphorus. Although in yielding the biuret reaction, and a precipitate on the addition of ammonium sul-

[1] Brieger and Georg Cohn, *Zeitschrift für Hygiene*, 1893.

phate, the toxine of tetanus resembles proteids as well as many other substances, it is concluded that the specific tetanus poison does not belong to the group of proteids, since it does not conform to the chemical behaviour of the members of this class. The amorphous cholera poison has also been studied by Brieger and Cohn, by cultivating upon Ouchinsky's medium without the magnesium sulphate. In the ordinary acceptation of the term this also appears not to be a proteid body.

The toxines isolated by these authors doubtless represent a highly concentrated form of the poison, since ·23 mg. would be the lethal dose for an adult man. Its virulence is evident when compared with atropin and strychnine, 130 mg. and 30-100 mg. being the smallest lethal doses of these alkaloids. Still it is possible that this research has not yielded the specific toxine. It is proved by the investigations of many workers that the amorphous products of micro-organisms may be both harmful and beneficial to the organism; these bodies may appear as an expression of the synthetic activity of certain bacteria, and may even exist within the protoplasm, but the essential physical and chemical characters of substances which may be as imponderable as enzymes are at present unknown. Just as the manifestation of peptic or amylolytic power is the only available test of the presence of pepsin or ptyalin, so the specific intoxications produced by the poisons of specific micro-organisms are in many cases far more characteristic and defining than the application of any chemical or physical tests which, at the present time, are at our disposal.

GEORGE A. BUCKMASTER.

# THE PRESENT OUTLOOK OF VERTEBRATE MORPHOLOGY.[1]

## I. *General.*

THE last quarter of a century will ever remain memorable in the history of animal biology as the period of what may be termed the embryological reaction. At its outset, the field of comparative embryology, first entered by von Baer, followed by Allen Thomson, von Kolliker and Haeckel, under the application of new methods by hundreds of willing explorers, gave promise of revealing the stages through which the diverse forms of animal structure have been attained, and, correlatively, of enabling us to form at least a sounder conception of the complex inter-relationships of animal forms, and of the characters demanded of the ancestral "Urthier" and of the lines along which to seek that. During the period, which will always be associated with the names of Balfour, His, Dohrn, the Brothers Hertwig, Van Beneden, Duval, Kowalewsky, Whitman, and Minot, as leaders in the great European countries and America, the conception that ontogeny is generally recapitulatory of phylogeny seemed early destined to prove a reality, and the advancing structural complexities of the organs in the ascending series of animals appeared to be the direct effects of a correspondingly progressive functional differentiation of the animal body. As a natural consequence of this, and in accordance with the generally accepted belief that land animals have for the most part had an aquatic origin, and that the fresh-water creatures have mostly been derived from aquatic ancestors, attention became more and more concentrated upon the lower classes of marine invertebrates; and so violent was the reaction that the department of vertebrate morphology, within which the foundations of the science had been built up, lay at

[1] *Apropos* of the appearance of Kükenthal's "Vergleichd-anatomische und entwicklungsgeschz Untersuchungen an Waltieren" (*Denkschr. d. Medic-Naturwiss. Gesellsch. Jena*, Bd. iii., 1889-1893, 366 pp. and 25 plates) and Semon's "Zoologische-Forschungsreisen in Australien und Malayischen Archipel.," i. (*ibid.*, Bd. iv., pp. 50, with 8 plates), 1893.

one time under a cloud of disrespect, and but for the loyalty of the minority it might have languished. To-day the cloud has passed and the reaction is subsiding—only to show that much that is developmental is, after all, adaptive, and that ontogeny is certainly not so strictly recapitulatory as was originally surmised. The conception of the mesoderm as a distinct embryonic layer, equal in importance with the remaining two, has been challenged,[1] and other of the most fundamental propositions of the germ-layer theory are now laid under arrest.[2] Dalamination has been discovered in Ophinroids[3]—the Plakula and Parenchymella theories of Metazoan development have now to be measured against the Gastræa one[4]—and the discovery of *Trichoplax*[5] and *Salinella*[6] (should the latter be confirmed) suggest altogether new lines of approaching the vitally important study of the structural relationships between the Protozoa and Metazoa. The doctrine of the substitution of organs[7] at least offers a provisional method of solving some of the most formidable difficulties which beset the evolutionist, and renders intelligible much that is most curious and perplexing in nature.[1] The earliest stages in Metazoan development are now proving to be as susceptible to secondary modification as the later ones, and signs are now dawning that even the respective value of the blasto-meres must be determined by their ultimate fate.[8] The brilliant researches of Julin[9] and others, now progressing, which are fast bringing us to regard the protozoan meganucleus as at least the functional counterpart of the nucleolus of the Metazoa, and its micronucleus as that of their remaining nuclear mass, once more revive the conception of the structural unity of

[1] To wit, the appearance of the electric organ in the *Raiidæ*. The conversion of the tail of the non-Torpedine Batoids into either a vestigial stump (*Pteroplatea*), an elongated whip-lash, or a barbed organ (*Tryonidæ*) strongly favours the conclusion that the development of an electrical organ within it is but one of a series of changes which it has undergone upon the usurpation of its function as the chief propeller by the expanded pectoral fins. The case appears akin to that of the independent development of pharyngeal sacs (proved by experiment to be indispensable to respiration) under accompanying reduction of the gills in the Muræ-noid *Amphipnous* (here reduced to one pair) and the siluroid *Sarrohanchus*.

the animal cell. The differences between the Protozoa and Metazoa to-day appear to be certainly non-qualitative,[10] and the essence of organisation, as Whitman has lately pointed out,[11] appears to no more lie in the "number of nuclei than in the number of cells," while "comparative embryology reminds us at every turn that the organism dominates cell-formation, using for the same purpose one, several, or many cells"; and the view that the part played by cell-division in the mere formative processes of the animal body is the all-important one that it at first sight appeared is on the decline.

Midst this changing scene, recent investigations, such as those of His,[12] Duval,[13] Hochstetter,[14] Mitsukuri,[15] and Beard,[16] have shown that, on the most rigidly definable embryological grounds, the vertebrate remains, to say the least, as interesting and important as the invertebrate. Palæontology has yielded us, in the Eotetrapoda[17] of Credner, a group of animals which so completely unite the Rhynchocephalia with the Stegocephala, that it is a question whether the line must not be drawn between the former and other lizards rather than between the Lizards and Amphibians; and in the Myxinoid *Palæospondylus*,[18] with its calcified notochord, it has unearthed the remains of a creature fit to rank in importance with *Archæopteryx* and the *Odontornithes*. The discovery of the Australian Mole Marsupial *Notoryctes*,[19] in revealing to us a unique example of isomorphism and convergence in nature, has emphasised a far-reaching principle which there is reason to believe has been too generally overlooked; and the recent discovery of lungless Salamanders in America[20] (if true), and, in Burma, of a snake having the external appearance of a harmless Colubrine, but the mouth of a viper,[21] would be hard to beat, among the sensational and unexpected; while the recognition of two new vipers within the European area is a theme with a sufficiently obvious refrain.

It will thus be seen that the vertebrate morphologist has reason for sustained confidence in his subject, and ample reward for his loyalty. The course of advancement has, within the period named at the outset, revolutionised his

conceptions of the inter-relationships of certain of the great classes of animals with which he deals, by striking at the most diagnostic of their morphological differences; and it may be well to briefly recapitulate some of the more salient of its points, beyond what has been already said, before considering the two monographs specially under review.

The discovery of the complex nature of the post-caval vein, and of the existence in certain fishes of a post-caval sinus,[22] together with the confirmation of Günther's discovery of a true vena cava inferior in the Dipnoi,[23] at once cuts into the root of the ichthyopsidan stem; and that of salient points of morphological community between the oral hypophysis of vertebrates and the ciliated sac of Amphioxus and the Tunicates,[24] adds a link to the chain which binds these animals together—a link rendered the more secure (i.) by appreciation of a parallelism of modification of the organ in Amphioxus and the Marsipohanchii, as diverse from the Tunicata and all higher vertebrates,[25] and (ii.) by the discovery in the Tunicate *Oikopleura flabellum* (?) of an abbreviated condition of the endostyle akin to that of the Ammocœte.[26]

The importance until recently attached to the characters of the occipital condyle is too familiar to need further mention here, but the fact that in many birds and reptiles the conditions are such that it might well be a nice point in law to decide whether a single or double condyle is present somewhat undermines this. The well-known fact that, in Mammals more especially, the roots of the hypoglossus nerve arise recurrently with the ventral ones of the spinal series and perforate the dura mater (and in many cases the skull also) by distinct apertures, has become luminous to an unexpected degree, by Froricp's brilliant discovery[27] of their dorsal ganglionated roots in the embryo ungulate. The investigations of Sagemahl,[28] Gegenbaur,[29] and others, which have followed this, and the discovery of the persistence of dorsal hypoglossal roots in Protopterus[30] and Polypterus,[31] render it now tolerably clear that, while in the Amphibia the hypoglossus nerve-bearing region has gone over to the vertebral column, and in the Amniota it has become merged into the occiput, in the Osteichthyes

more especially the incorporation of one or more differentiated vertebral segments, or at least their associated arches, in the skull, is apparently the rule—the so-called occipital articulation being inter-vertebral. In view of these facts, and others, well known, involving variation of the occipital and anterior-vertebral regions of the axial skeleton, the taxonomic value in the past attached to the presence of a single or double condyle is materially lessened, if not nullified.

The mention of the last-named topic leads up naturally to a consideration of the Mammalia, believed by some to be most nearly allied to the Reptiles and by others to the Amphibia. The classical researches of Gœtte[32] have, within the last twenty years, laid the foundation for a complete reconciliation between the distinctive features of the shoulder-girdle in Mammals and certain Reptiles. The inter-clavicle, originally thought to be formed in Monotremes alone among Mammalia, has been found to appear during development in the Placentalia; and the segmentation of the coracoid into superposed epi- and meta-coracoidal elements has been observed in representative members of the leading orders of Placental[33] Mammals. The marked differences between the adult condition of the hip-girdle of *Ornithorhynchus* and that of all other mammals have been found to be due to change occurring late in ontogeny;[34] and the discovery of the independent development of epipubic supports for the abdominal wall in the Amphibia, Reptilia, and Mammals,[35] has lessened the value of these as guides to affinity to the utmost. Both in respect to their fundamental constitution and disposition, the limb-girdles of mammals and certain of the anomodont reptiles stand now agreed and alone. That these resemblances are indicative of mere convergence by independent modification, rather than of a direct genetic relationship, might well appear, by analogy to Haacke[36] and Giacomini's[37] discovery of the independent acquisition of true vitelline and allantoic placentæ of the mammalian type by the Scincoids. That they are not so, however, is most certain, from the fact

that they go hand in hand with a corresponding phalangeal formula and minor resemblances of a more detailed kind.

II. *In Review.*

The first of the two monographs which have called forth this article deals with the Cetacea, a group of animals of notoriously aberrant organisation, peculiarly associated with the past history of the science of gross anatomy in our own land; and not a few of the more striking discoveries which it announces have been made during the author's study of material preserved in our National Museum. The interest which of old centred in these colossal denizens of the deep—the largest of all known animals living or extinct—has of late been materially increased (i.) by the discovery of an apparently herbivorous Dolphin in the Cameroons[38] with its anterior nares prolonged up into a couple of tubes, for which a parallel exists only among the Osteichthyes and certain frugivorous bats,[39] (ii.) by the surmise that, by analogy to certain Mammals and Reptiles of the past, their colossal stature may be indicative of their approaching near extinction,[40] (iii.) by the probable extermination of one species within recent years,[41] (iv.) by the bold generalisation of Albrecht[42] that the living mammalia should be divided into Cetoid and Non-cetoid sub-classes, of which the latter are the more primitive (which, although more sensational than sound, has served the good purpose of stimulating research); and last, but not least, (v.) by the series of brilliant preliminary communications, from time to time issued by the author of the work now under review.

The Kükenthal monograph embodies the results of seven years' close and laborious investigation, and for the first time puts the study of Delphinology upon a secure embryological basis. It was commenced upon material given its author by Professor Haeckel, and largely continued upon that collected by himself during a couple of expeditions to East Spitzbergen, under the auspices of the Bremen Geographical Society, further famous for the capture of a new variety of *Lepidurus*,[43] and material for the fuller elucidation of the extremely rare *Proneomenia Sluiterei*.[44] The work was published in two parts, the first

appearing in 1889 and the second in 1893, and it is divided into six chapters of variable length. The first of these is devoted to a full description of the skin, and, returning to this in a later chapter, the author, confirming and extending Gray's discovery of dermal ossicles in the Delphioidea, builds up an argument that the toothed whales may have had mailed ancestors. He deals with the development of the limb skeleton in an almost exhaustive manner; and not the least remarkable discovery is that the numerical reduction of the digits to four in the whalebone whales, other than the Balænidæ, well known, is in *Balænoptera musculus* due to the loss of the third digit, and not to a suppression from within outwards, supposed to be the rule among mammalia generally—a fact incidentally the more interesting and suggestive in consideration of Forbes's discovery[45] that in tridactyle birds it is not always the hallux that is suppressed. In dealing with the vexed question of hyperphalangy, the author formulates the facts observed by himself and others concerning the numerical variation of the phalanges at different stages of growth, and shows that in all known cases their number diminishes with age—a most interesting feature, as remarkable as unexpected, inasmuch as it proves those forms which, like the *Platanista*, may in the adult state present the characteristic mammalian formula 2 . 3 . 3 . 3 . 3, to be thus far the most highly modified members of the order. In estimating the morphological value of the supernumerary phalanges, he avails himself of Leboucq's discovery[46] of the nail rudiment and its apparent constancy of relationship to the free end of the digit at observed stages in growth, a discovery which, whatever the value of supernumerary elements, proves these to be intercalary, and deals the death-blow to Ryder's fascinating hypothesis[47] of their origin in catilaginous rays of the eared-seal type. Kükenthal believes the "supernumerary phalanges" to be duplicated and dismembered epiphyses, and in support of his view falls back upon the discovery by Allen Thomson[48] and others of the occasional presence of these among the more normal mammalia. He records the existence of

centralia in the carpus, and formulates the known variations of the carpal elements in general; and he incidentally describes an occasional cleavage of the innermost digit, and the convergent resemblances between the Cetacean and Ichthyosaurian paddles. The interest of this topic has since vastly increased during the study of the Crocodilia; for Kükenthal himself has shown[49] that the fourth and fifth digits of these animals, vestigial in the adult, are in the embryo hyperphalangeal. From this discovery he deduces a belief in their origin from more completely aquatic, and probably marine, ancestors, of intense interest in its bearings upon Röse's recent inquiry[50] into their tooth-genesis. It seems not a little significant under this head to reflect on the striking similarity, presumably due to mere convergence under adaptation to a similar mode of life, which the rostra and teeth of the Cetacean *Platanista* and the Crocodilian *Gavialis*, living side by side in the Ganges, present.

The third chapter, written conjointly with Dr. Theodor Ziehen of Jena, deals with the nervous system, and more especially the homologies of the brain convolutions in these animals and the Pinnipedia, as compared with those of the leading orders of placental mammals; and the authors' conclusions[51] are considerably at variance with those of Turner, published two years later, in apparent ignorance of their work. The authors deduce four laws of development and variation of brain convolution, and an allied section of the work is devoted to the sense organs, the nasal organ of the Cetacea on comparative embryological grounds being reduced to that of the ordinary mammalian type. The detailed facts recorded, receive a welcome corollary in Hill's[52] recent assertion that the fascia dentata and olfactory bulb are correlatively variable with each other and the olfactory organ, and in this section the conclusion is emphasised that the Cetacea of to-day may be a diphyletic assemblage—a conclusion of no little moment, in relation to current belief in a similar origin for other great groups of living animals of high structural organisation.

The second part of the treatise is devoted more especially to embryology, and opens with an elaborate table of variation in external form during development. The succeeding chapter is a most important one, and deals, among other things, with the first indications of the vestigial hind limb. The lingual musculature, the study of lip-formation in relation to lactation under water, the development of the external ear, and the morphology of the mammary organ, are in order considered; and the volume closes with a chapter on the teeth, in which, controverting the earlier conclusions of Eschricht, Julin, and Max Weber, the author elaborates his now famous argument for the origin of the Cetacea from heterodont diphyodont ancestors, with accompanying numerical increase of their teeth by subdivision—on the whole the most revolutionary outcome of his labours. He deals with the variations upon this theme, and shows that while, during the fœtal life of the whalebone whales, the teeth of the milk set alone reach the calcified condition, among the Odontocœtes, calcified milk and successional teeth may, by fusion, give rise to a single complex derivative.

While there can be no two opinions as to the value of Professor Kükenthal's observations, there are one or two side issues which, without going into critical detail, call for special comment. His conclusion that the cerebral furrows are nutritive depressions which mark the disposition of the leading circulatory channels, is of especial interest at the present time, when it is doubtful whether the leading fissures of the mammalian brain really mark out the boundaries of localisable areas of response to artificial stimulation. They are the more suggestive in consideration of Cunningham's surmise [53] that the transitory fissures, which appear in the human fœtus, only to vanish as the vault of the cranium increases, are of mere passing mechanical origin, and of the most careful investigations of Forsyth Major,[54] which have quite recently shown us that the Lemurine brain undergoes, during the growth period, a diminution in bulk, if not a structural simplification also, proportionate to the rest of the body, and that have led him to the startling conclusion that those Lemuroids and Insectivora, possessed

of a small smooth brain and long face, are perhaps the (by degradation) most aberrant members of their orders, rather than the lowest, as has been on all hands hitherto assumed —or, as Fürbringer has aptly remarked of the Ratite Birds, that they are "pseudo-primitive".[55]

His arguments concerning the origin of the homodont dentition, with numerical increase of teeth, by subdivision of a less numerous heterodont one, appear well founded; but the assumption that the setting free of the fangs of the tooth of a seemingly senile Seal, by a process of natural wearing away of the crown, is indicative of the nature of the activities originally at work in the evolution of the Cetacea, is an absurdity; and the argument that, because evidence of the aforementioned subdivision is forthcoming in the ontogenetic development of the latter order, the converse holds good, that the heterodont teeth of their ancestors must have arisen by fusion of simple conical teeth of an approximately reptilian type, is illogical, if not opposed to the known revelations of palæontology. Incidentally to this section of his work, the author reverts to his investigations into the comparative odontology of the Mammalia, and to his epoch-marking discovery that the teeth of the polyprotodont marsupials are, with the exception of the well-known successional pre-molar, all of the first or milk series. It is not a little remarkable that the subsequent investigations of Woodward,[56] while confirming this deduction and showing that, in all probability, the single successional tooth so called is, in the Macropodidæ, but a displaced member of the common series, variable in its secondary relationships with its fellows in closely allied species, should leave it at present very doubtful if the Diprotodont molars are not of the second series.

We welcome with satisfaction Kükenthal's discovery of tegumental elevations, like those which in the land mammals give rise to the pinna of the external ear; but we cannot accept his doubts concerning the real nature and morphological value of that structure originally described as a vestigial pinna in the porpoise and white whale.

The author promises a third part of his monograph, to be devoted to a consideration of the soft parts, upon which Max Weber [57] and Turner [58] have recently thrown so much light, together with a final discussion of the position of the cetacea in the animal series. Meanwhile, he has earned the lasting gratitude of all, in having simplified our conceptions of the structural peculiarities of these remarkable creatures, and brought them into much closer harmony with the more normal placentalia.

The dipnoan fishes, to a consideration of the early stages in development of one of which the second of the two monographs specially under review contributes a first instalment, are represented by three living genera of fresh-water fishes—*Ceratodus* in Queensland, *Protopterus* in Tropical Africa, and *Lepidosiren* in the Amazons—and all doubt as to the supposed non-validity of the last-named genus is dispelled, by the authoritative record of six known examples preserved in the European museums.[59] The classical monographs of Hyrtl,[60] Günther [61] and Huxley [62] upon the gross structure of these creatures, and the supplemental ones of Gegenbaur,[63] Wiedersheim,[64] Parker [65] and others, need no comment here, except that, in having proved these fishes to differ from all others in proportion as they suggest the amphibian type of organisation, they bring us in touch with an approximate realisation of the characters demanded of those creatures transitional between the aquatic and terrestrial vertebrata —a topic of obviously supreme interest and importance.

Huxley has defined *Ceratodus* [66] as a "wonderful creature contrived for the illustration of the doctrine of evolution". It cannot, however, be denied that the experimental and morphological inquiries into the acces sory organs of respiration occurring among the Tropical Teleosteans,[67] and those of Johannes Müller [68] and Ramsay Wright [69] concerning the behaviour of the pneumatocœle and aortic arches in *Polyterus* and *Amia*, justify hesitation, in accepting the customary belief in an intimate genetic relationship between the Dipnoi and Amphibia. The

lung-sac of the Dipnoi is much more lung-like and their atrial septum is more complete than that of some Urodeles, but the probability that this simplification may be the outcome of a substitution of organs, with accompanying structural degeneration, must not be overlooked. Whatever the truth, the Dipnoi stand alone among fishes in the possession of the septum auricularum and a pulmonary vein and posterior nostril; and not the least important desideratum concerning them, is the settlement of the question whether the latter is or is not the homologue of that of the terrestrial vertebrata. The belief in the so-called archipterygial characters of the paired fins of *Ceratodus* has not met with general acceptation; and although the "archipterygium" theory is still upheld by palæontologists, the detailed characters of the paired fins of the Palæozoic Selachians *Cladodus* and the *Xenacanthidæ* are by no means readily reconcilable with those of the *Ceratodus* type.[70] And not the least formidable difficulty which besets their argument is the fact that the biserial condition is not forthcoming in the pelvic member of these old elasmobranchs. There are not wanting those who, with Haswell,[71] believe that "the limb of *Ceratodus*, so far from representing a primitive and generalised type, is, as indeed we should expect from various other points in the organisation of the animal, in reality highly specialised".

Professor Semon's previous work ranks high among contemporary scientific investigation, and, if only in consideration of the above-cited difference of opinion on a subject so important to the vertebrate morphologist as that which he now has in hand, his work, striking as it does at the very foundations of one of the most central groups in the vertebrate sub-kingdom, cannot fail to reveal facts of a revolutionary order. The two short chapters of his treatise thus far published are largely prefatory in nature. They open with a history of the genus, and an account of its distribution and habits. The author controverts the assumption of the animal's alleged migration on land, and confesses himself, like Spencer,[72] unable to find evidence of the imagined summer sleep, presup-

posed by Krefft on analogy to Protopterus, making a noble point in his observation that the period of low water in the Burnet River is that of Ceratodus' reproduction. He draws the remarkable inference that although the animal devours vegetable matter, it nourishes itself upon the various small creatures associated therewith, chiefly because he has observed the injested green food to pass little, if at all, changed through the alimentary canal. Concerning the functions of the lung-sac, he has made experiments which lead him to the conclusion that that organ is chiefly functional during respiration in bad or insufficient water, and the experiments show not a little analogy to those of Day and others made upon Tropical Siluroids and other fish already alluded to. It is unfortunate that he should not have ascertained the results of complete deprivation of access to the surface of clear water.

Disposing briefly of the few observations made on oviposition, the author proceeds to consider the external phenomena of development, up to the time of first appearance of the pelvic fins; and furnishes in illustration eight magnificent plates. Cleavage of the egg is total and unequal, and comparable in important aspects to the amphibian type. There is nothing in the development of the posterior nostril, as thus far observed, in any way opposed to the supposition that it is homologous with that of the terrestrial vertebrata. The first appearance of end-organs upon and in the neighbourhood of the lateral line in the form of papillate upgrowths appears of special interest, in relation to Fritsch's discovery[73] of "spaltpapillen" in the lateral line region of Elasmobranchs. The pectoral fin is at first rounded in contour with a central tapering axial lobe; but with enlarging growth (as judged by the drawings) it loses its regularity and assumes a more angular and ordinary fish-like shape.

There are no traces of either larval gills or suctorial apparatus; and the author, laying stress upon this, controverts the view that the suctorial mouth of the amphibian larva is a reminiscence of a cyclostome stage in evolution. We most heartily agree with him. The

view that the amphibian metamorphosis is recapitulatory is now losing ground.[74] The entire absence of metamorphosis in the Urodela, and of horny teeth and sucking lips in the tadpole of *Xenopus*, the wholly aquatic anuran, are formidable difficulties in the way of its acceptation; and the mind reverts rather to the inner gills and retention of branchial passages by the Derotremata as an infinitely surer mark of the fish.

Professor Semon's material was accumulated during a two years' sojourn in Australia and the Malay Archipelago, and in his prospectus he tells of the acquisition, in additions of embryos and adults, of Monotremes, Marsupials and Sirenians, together with members of the leading classes of the animal kingdom. He has apparently more than covered the ground gone over by our countryman, Caldwell, years ago. While, as Englishmen, we confess to a feeling of bitter regret that the Caldwell collections should have been allowed to remain in oblivion, under the cosmopolitanism of true science, we rejoice in the present prospect, and in the wisdom of Professor Semon's having distributed his material among specialists of recognised ability, for immediate investigation.

Professor Semon's expedition was undertaken at the expense of Dr. Paul von Ritter, who eight years ago endowed the Professorship of Phylogeny in the University of Jena, which bears his name, and the spirit of his noble liberality and enterprise is being followed by Gustav Fischer, in the magnificent manner in which the two great treatises before us are being published. It is a matter of sincere congratulation that the University of Jena, which has done so much for the study of the Invertebrata, is now becoming the centre of special work upon the opposite sub-kingdom.

The monograph is prefaced by a brief account of the expedition, and some general remarks upon the countries visited. In connection with the scheme, Professor Haeckel has written an introductory essay upon the generalities of the Australian fauna. Great, however, as must be the regard in which men of science hold the work of the

distinguished Zoologist of Jena, it must be frankly admitted that his present essay loses much of its force for want of proper recognition of palæontology.

### III. *In Conclusion.*

It will, I trust, be sufficiently evident, from the promise given by the two treatises afore-considered, and the tendencies of contemporary investigations cited, that the outlook in vertebrate morphology is rosy beyond anticipation. During the period of the close of which the former are so conspicuous a feature, that steady work which tells most in the long run has been progressing on all hands. The combined energies of Fürbringer,[76] Seebohm[77] and Gadow[78] have given us revised classifications of birds. Both at home and in the New World the remains of Dinosaurs of unexpected beauty, hideousness, and structural aberration combined, have been unearthed; and the clue to the affinities of the anomalous "Enaliosauria" has been obtained.[81] Our American brethren have dazzled us with a galaxy of Mammalian remains of bewildering complexity, which, while they have materially modified our conceptions of the inter-relationships and elucidated the phylogeny of the Placentalia, show to us that, beyond doubt, in Eocene times these mammals were having their day, and branching out into innumerable specialised varieties destined to near extinction. The Old World has yielded us links in the anomalous giraffine series of mammals.[82] Steady work in the palæontology of fishes has largely cleared up the mystery of the "Placodermi,"[83] and, in correlation with that of Huxley[84] and Boas[85] on the living Osteichthyes, has laid low[86] the assumed sub-ordinal value of the Ganoidei. Advancing investigation has so far demonstrated the enormity of the structural gap between the higher fishes and the Marsipobranchii, as to have justified their removal from the truly piscine category;[87] and the pineal eye, so recently independently discovered by De Graaf[88] and Spencer,[89] the structural features of which in these animals have

been found suggestive of a morphologically paired nature, has recently become the centre of a renewed interest, in the assertion[90] that it appears early in development as one of two pairs of bilaterally symmetrical organs, serially recurrent with the paired eyes. And the far-reaching significance of this (if true) is none the less interesting, in view of the long-recognised suggestion of a paired nature by the median Crustacean eye, and the fact of the persistence of this in adults of even the Decapod group.[91]

On all hands one meets with reform by progressive development along continuous lines of inquiry, with sure indications that true progress in science does not march by leaps and bounds, but by an evolutionary process of gradual unfolding, under which each step in advance bears the impress of those immediately antecedent to it. Future historians will unmistakably have to chronicle error due to the too exclusive devotion to pure embryology, which so unconsciously lends itself to over-generalisation, and to the attempt to force the extinct into a too rigid classification with the living. Experience shows that whole groups of animals have dropped out of existence, and that the exclusive study of the embryology of animals, like that "of anatomy" of plants, lends itself to the accumulation of meaningless detail, as does that of mere histology to a sort of laborious idleness. The study of ontogenetic development must be pursued hand in hand with that of adult of anatomy and palæontology[92]—gross morphology if anything leading the way—the three being as fully interdependent as are the allied pursuits of histology and experimental physiology. It cannot be denied that, for the bare want of appreciation of this principle, much that has been written within the period which we have named has become, in its own time, valueless; and it is only by rigid adherence to this that the study of animal morphology can retain that honoured position among the sciences of which its devotees are justly proud.

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# CHEMICAL PHYSIOLOGY.

I PREFER the term Chemical Physiology to that of Physiological Chemistry, because the branch of science of which I have to treat here is a department of physiology rather than of chemistry proper. A glance through the various journals of physiology, both in this country and abroad, will show how very largely the chemical aspect of this subject is studied and investigated at the present time. I propose in my present article to give a summary of the most important of these papers, which have been published recently, especially those that appeared last year.

*Carbohydrates.*—Glycogen has been the subject of numerous researches. S. Fränkel (Pflüger's *Archiv*, lii. 125) has introduced a new method of preparing this substance from the animal tissues. It consists in the use of a 2-4 per cent. solution of trichloracetic acid as the extracting agent. Fränkel also regards it as probable that living cells do not contain glycogen as such, but in the form of a complex compound with proteid material. Fränkel's method has been severely criticised by Weidenbaum (*ibid.*, liv. 319), who shows that the acid solution does not merely dissolve glycogen, but a considerable quantity of proteid as well; moreover, a certain amount of glycogen is left in the tissue.

V. Kistyakoffsky (*J. Russ., Chem. Soc.*, xxv. 60) recommends a very similar method of cold extraction of glycogen, using a 1-2 per cent. solution of hydrochloric acid.

The specific rotatory power of glycogen is given by Fränkel as $(a)^{D} = 197{\cdot}891^{\circ}$. Huppert (*Zeit. physiol. Chem.*, xviii. 137) gives this value as $196{\cdot}63^{\circ}$.

Huppert (*Centr. Physiol.*, vi. 394; *Zeit. physiol. Chem.*, xviii. 144) finds that glycogen is present in blood (5 to 10 milligr. per litre in ox-blood) and in pus. The leucocytes are the source of the glycogen found here. G. Salomon

(*Centr. Physiol.*, vi. 512) points out that he observed these facts as far back as 1877. Dr. Noel Paton (*Brit. Med. Jour.*, 1893, ii. 682) has investigated the influence of fever on the glycogen of the liver; a high body temperature diminishes the hepatic glycogen, the reducing substance of the blood being correspondingly increased, probably indicating sugar formed from the glycogen. A paper by Dewevre (*Compt. Rend. Soc. Biol.*, 1892, 19) gives the rate of disappearance of glycogen from the liver and muscles of frogs during the period of hibernation.

Coming next to the sugars, that in the blood is proved to be dextrose by the phenyl-hydrazine test (Pickardt, *Zeit. physiol. Chem.*, xvii. 217), as is also that in muscular tissues (Panormoff, *ibid.*, xvii. 596). The conversion of maltose into dextrose is found to be accomplished by the mucous membrane of the intestine, probably partly by the intestinal juice, and in part by the cells themselves; the lymphoid cells appear to be less important for this purpose than the epithelium cells (Shore and Tebb, *Proc. Physiol. Soc.*, 1892, 19). A diastatic ferment in blood serum and lymph discovered by M. Bial (Pflüger's *Archiv*, lii. 137) differs from similar ferments by converting starch, not into maltose, but into dextrose. The carbohydrates of normal urine have been investigated by K. Baisch (*Zeit. physiol. Chem.*, xviii. 193) by the benzoic chloride method. Two were found, one of which gives the tests for dextrose. With regard to diabetes, F. Voit (*Zeit. Biol.*, xxix. 129) finds that carbohydrate is not available as a proteid-sparing food in this condition, and (*ibid.*, 147) that galactose does not increase the hepatic glycogen, though it causes a rise in the sugar of the urine. Diabetic coma can be produced in dogs by intravascular injection of sugar, but it is probably produced by the formation of acid products therefrom (V. Harley, *Brit. Med. Jour.*, 1893, ii. 666; *Jour. Physiol.*, xv. 139; *Proc. Roy. Soc.*, liv. 179).

*Fats.*—The melting-point and composition of butter from cows variously fed has been treated by A. Meyer (*Landw., Versuchs-Stat.*, xli. 15), and the composition of over-ripe cheese by A. Maggiora (*Exper. Stat. Record*,

iv. 98). O. Frank (*Arch. Anat. und Physiol., physiol. Abth.*, 1892, 49) shows in dogs that absorption of fats continues to a considerable extent after ligature of the thoracic duct. In a long polemical paper Pflüger (Pflüger's *Arch.*, li. 229) discusses the question as to whether fat originates from proteid in the body; he admits the possibility, but strenuously urges that proteid, and proteid alone, is the source of muscular energy. The complex fats of nervous tissues have been investigated by A. Kossel and F. Freytag (*Zeit. physiol. Chem.*, xvii. 431); they find the substance protagon is not a single material, but there is more than one protagon. They yield derivatives called cerebrin, kerasin and encephalin, in addition to lecithin, which again appears to consist of several varieties.

*Proteids and Albuminoids.*—The subject of fractional heat coagulation in connection with the proteids of egg white has been the subject of two papers—one by Ramsden (*Proc. physiol. Soc.*, 1892, 23), who does not believe in the value of the method; the other by Hewlett (*Jour. Physiol.*, xiii. 493), who defends it. The latter observer has also (*ibid.*, 798) subjected the proteids of milk to a rigorous examination; he finds that in addition to caseinogen and lactalbumin, cow's milk contains minute traces of a globulin. For the most recent work on crystallisable vegetable proteids, the reader should consult a paper by T. B. Osborne (*Amer. Chem. Jour.*, xiv. 662). The proteid reactions have been the subject of an exhaustive research by J. W. Pickering (*Jour. Physiol.*, xiv. 347), the most important results being that cobalt salts give characteristic colour plays in alkaline solutions of proteids, which like those produced by the closely-related metals, copper and nickel, differ in the classes of native proteids, and the products of proteolysis (proteoses and peptones) respectively. Native proteids give with cobalt a heliotrope-purple; proteoses and peptone, a red-brown. It is probable that these reactions with metals, which include the well-known biuret reaction, are due to the presence and arrangement of a CONH group.

Nucleic acid, the organic acid which contains the phosphorus in nucleins, and nucleo-albumins has been the subject of renewed research by A. Kossel and J. Horbaczewski (*Chem. Centralbl.*, 1893, 787, 788). The former has investigated the chemical side of the question, and the latter re-affirms his position on the formation of uric acid from the nuclei of cells. In connection with this subject, it is necessary to allude to an important work by L. Lilienfeld and A. Monti (*Zeit. physiol. Chem.*, xvii. 410), who by the use of ammonium molybdate and a reducing agent (pyrogallol) have been able to demonstrate the presence of phosphorus in the tissues and organs microchemically.

We next come to the investigations which relate to the proteids obtainable from various tissues and organs. C. T. Mörner (*Zeit. physiol. Chem.*, xviii. 61) has examined the proteids of the crystalline lens; he finds two globulins which he designates crystallin-$\alpha$ and crystallin-$\beta$, a trace of albumin, and an insoluble albuminoid. In a later paper treating of the other refractive media of the eye (*ibid.*, xviii. 213) he deals especially with their mucinoid constituents.

The proteids of liver and kidney cells, and of nervous tissues, have been studied by W. D. Halliburton (*Jour. Physiol.*, xiii. 806, xv. 90); he devotes special attention to the nucleo-albumins, the substances which Wooldridge termed tissue-fibrinogens. He has introduced a new method of preparing them, and finds that they produce intravascular coagulation, as when prepared by Wooldridge's method, even when freed from all lecithin. L. Liebermann (Pflüger's *Archiv*, l. 25, 55, liv. 573) has introduced the term lecithalbumin. This compound he has separated from intestinal epithelium cells, and from kidney cells, by subjecting them to gastric digestion; the insoluble nuclein-like residue contains, he believes, lecithin in actual combination.

The proteids of spleen and thyroid are similar to those obtained from other cellular organs. There is, however, this point of interest to be noted, namely, that the colloid

substance in the thyroidean acini is not mucin; it yields no sugar on treatment with mineral acid, and it gives evidence of phosphorus by Lilienfeld's new method; presumably it is a nucleo-albumin (Gourlay, *Proc. Physiol. Soc.*, 1893, viii.).

The peptones have been the subject of three important papers; one by Kühne (*Zeit. Biol.*, xxix. 1), who enters with full details into the use of ammonium sulphate for the separation of peptones from proteoses, and defends his position against the attacks of Pekelharing, who does not consider that any essential difference exists between peptone and proteose. Kühne also investigated the diffusibility of these substances, and obtained the curious result that deutero-proteose is less diffusible than proto-proteose, a result independently obtained also by Chittenden (*Jour. Physiol.*, xiv. 483) in a comparative study of artificial and natural digestion. The second paper treats of the chemical structure of peptones, and is written by Schützenberger (*Compt. Rend.*, cxv. 764), a well-known worker in this field; and the third of an important physiological property of these substances by Starling (*Jour. Physiol.*, xiv. 131). When injected into the blood, "peptone" produces loss of power of coagulation; the peptone leaves the blood by the urine, *via* the lymph. It can be detected by adding to blood or lymph an equal volume of ten per cent. solution of trichloracetic acid; this precipitates the normal proteids of these fluids, and the peptone is discoverable in the filtrate.

In reference to albuminuria the most important paper of the year is by D. Noel Paton (*Proc. Roy. Soc. Edin.*, xix. 102), who has observed the unique phenomenon of the occurrence of a crystalline globulin in human urine.

The most important papers on albuminoids are the following: On mucin in bone, by R. A. Young (*Jour. Physiol.*, xiii. 803), who finds that mucin is absent from compact bone, the ground substance being entirely calcareous. On synovial mucin, by E. Salkowski (Virchow's *Archiv*, cxxxi. 304); this substance appears to be neither true mucin nor nucleo-albumin; it contains no phosphorus but yields no reducing substance. In an important paper by O. Ham-

marsten on human bile (*Konigl, Gesellsch. der Wissensch.*, Upsala, June, 1893), in addition to numerous analyses, the statement is made that the mucin is true mucin, not nucleo-albumin as in ox-bile. Chitin has been the subject of two papers by N. P. Krawkow; he points out (*Central. Med. Wiss.*, 1892, 145) that this substance gives a reaction with iodine like the albuminoid material found in waxy degeneration: he further (*Zeit. Biol.*, xxix. 117) from an examination of various invertebrate skeletons states that several varieties of chitin exist.

*Nutrition.*—This wide term includes the subjects of digestion of foods, and their value in general metabolism. Under the first head, the papers of Kühne and Chittenden on peptones and Hammarsten on bile have been already mentioned in preceding paragraphs. In addition to these there are other papers of which the most important are the following: On pancreatic juice in different animals, by Harris and Gow (*Jour. Physiol.*, xiii. 469). The tryptic ferment was found most constantly present, then the rennetic, then the diastatic; the fat-splitting ferment was often absent, and no special fat-emulsifying agent was ever found. On hydrolytic ferments, by H. Hildebrandt (Virchow's *Archiv*, cxxxi. 5); this relates chiefly to the toxic effects of, and fate in the body after subcutaneous injection of rennin, emulsin, and invertin. A certain amount of immunity is brought about by the administration of successive very small doses of these agents. On putrefaction in the intestines, by C. Schmitz (*Zeit. physiol. Chem.*, xvii. 401). Here it is shown that milk lessens putrefaction, as evidenced by the fall of ethereal sulphates in the urine; casein not lactose is probably the antiseptic agent. Hydrochloric acid in man but not in dogs acts in the same way. On the acids of ox-bile, by Lassar-Cohn (*ibid.*, xvii. 617); this gives quantitative analyses.

The papers on general metabolism are more numerous. H. Hildebrandt (*ibid.*, xviii. 180) confirms with careful experiments the already well-known fact that albumoses have a high nutritive value. E. Krauss (*ibid.*, xviii. 167) points out that, in calculating the value of nitrogenous

food, the loss from intestinal putrefaction is a factor to be reckoned with; and F. Hirschfeld (*Berl. klin. Woch.*, xxx. 324), who has shown that less proteid is compatible with health than was formerly supposed, insists that the weight, volume, and digestibility of proteid food are as important in the construction of dietaries as the consideration of their chemical composition. C. Schulz-Schultzenstein (*Zeit. physiol. Chem.*, xviii. 131) shows that infusions of tea and coffee considerably impede artificial gastric digestion. Allied questions are taken up by L. Breisacher (*Deut. med. Woch.*, 1891, No. 48), who, by experiments on himself, determined that 87 grammes of albumin are sufficient per diem; by C. Adrian (*Zeit. physiol. Chem.*, xvii. 616), who shows in dogs the increased value of proteid food when taken in four successive meals in the day instead of all in one dose; by W. Heerlein (Pflüger's *Archiv*, lii. 165), who shows that in rabbits the value of coffee is due to its stimulant action on the nervous system, and that it is not a food.

The never-ending subject of alcohol has been the cause of several papers, among which may be particularly mentioned one by C. v. Noorden (*Berl. klin. Woch.*, 1891, No. 23), who concludes that the calories of alcohol are well utilised with richly nitrogenous food, but not otherwise; and another by Strassman (Pflüger's *Archiv*, xlix. 315), who calculated that 90 per cent. of alcohol in moderate doses is utilised in the body.

A number of other papers on the nutritive value of foods and drugs we can only mention in passing; these are: on the nutritive value of bread, by Zuntz and Magnus-Levy (*ibid.*, xlix. 438); of asparagine, by G. Politis (*Zeit. Biol.*, xxvii. 492), and by J. Mauthner (*ibid.*, xlix. 507); of acetic acid, by A. Mallévre (Pflüger's *Archiv*, xlix. 460), and of cellulose, by N. Zuntz (*ibid.*, xlix. 477); on the absorption of iron, see Kunkel (*ibid.*, l. 1), Macallum (*Proc. Roy. Soc.*, l. 277), R. Stockman (*Brit. Med. Jour.*, 1893, i. 881, 942), and C. T. Mörner (*Zeit. physiol. Chem.*, xviii. 13).

On general metabolism, there are several important

papers. Thus we find one by Pflüger (Pflüger's *Archiv*, lii. 239), which is interesting, but long and very polemical. It relates to nutrition with carbohydrate and flesh, and with carbohydrate alone. It is a critical account of the older experiments of Pettenkofer and Voit on this subject. By feeding on carbohydrate alone, fat is seldom formed, but in the admixture of carbohydrate with flesh, it is the carbohydrate and not the proteid of the meat that accounts for the fat deposited. Another polemical paper is by Seegen (*Chem. Centr.*, 1892, ii. 84), who, replying to Pflüger, maintains that sugar is normally produced in the liver, especially from proteid, and that sugar is the source of all the energy of the body.

The general metabolism in a child fourteen months old has been investigated by W. Camerer (*Zeit. Biol.*, xxix. 227); the most noteworthy fact appears to be the relatively small output of uric acid.

Metabolism during inanition has been the subject of two papers; in one by Prausnitz (*Zeit. Biol.*, xxix. 151) the period of inanition lasted for two days; the chief point noticed being that on the second day the output of nitrogen is often as large as, often larger than, on the first day. The other paper, of which the authors are C. Lehmann, F. Müller, I. Munk, H. Senator and N. Zuntz, forms a large supplement of 228 pages to volume cxxxi. of Virchow's *Archiv*. The subjects of experiment were professional fasters, and the fast lasted in one case ten, in another six days. The names of the authors are sufficient guarantee that the observations are of a thorough kind; indeed, we have here the most complete account extant of the conditions of starvation. The various portions of the subject, urine, respiration, circulatory organs and so forth, were divided among the investigators, and perhaps the most curious fact that strikes one on reading this exhaustive treatise is that after all the changes from the normal were so small.

*Respiration.*—The papers relating to this subject have not been so numerous as usual. Dr. Marcet (*Proc. Roy. Soc.*, l. 58) has continued his researches on the ratio be-

tween the absorption of oxygen and formation of carbonic anhydride in human respiration. J. Haldane and J. L. Smith (*Jour. Pathol. and Bacteriol.*, i. 318) have performed experiments on Merkel's plan, which were found to lend no support to Brown-Séquard's hypothesis, that air contains a special organic poison. These results confirm the previous statement by the authors, that the only toxic substance in expired air is carbonic anhydride. Respiration in fishes has been investigated by C. Duncan and F. Hoppe-Seyler (*Zeit. physiol. Chem.*, xvii. 165); the influence of light on gaseous interchange by C. A. Ewald (*Jour. Physiol.*, xiii. 84), who finds the influence is not appreciable if muscular action is eliminated; the influence of fatiguing muscular work on the respiratory interchange by A. Loewy (Pflüger's *Archiv*, xlix. 405). He finds that when work is excessive the normal ratio between intake and output is upset, and the respiratory quotient rises: and that during fatigue more muscular activity is expended in doing a certain amount of work than when the muscle is fresh. Another paper may be here alluded to, though it does not treat directly on respiration; it is on the action of nitrites on muscular tissue; the authors are J. T. Cash and W. R. Dunstan (*Proc. Roy. Soc.*, lii. 91); the full paper has since appeared in the *Phil. Trans.* (vol. clxxxiv., 1893, p. 505), and though it treats more especially of a pharmacological subject, will be found to present many points of interest to physiologists also.

Gaseous tension in the blood and serum of peptonised animals is treated of by V. Grandis (*Real. Accad. Linc.*, vii., ii. 471); the gaseous tension of carbonic anhydride is increased in these animals in the venous blood. The quantity of free carbonic anhydride in the serum is slightly increased; that of combined carbonic anhydride considerably diminished. The blood gases during anæsthesia have been analysed by Oliver and Garrett (*Brit. Med. Jour.*, 1893, ii. 683); an excess of nitrogen was found.

*Blood and Pigments.*—The coagulation of the blood

has been studied by A. E. Wright (*Jour. Pathol. and Bacteriol.*, i. 434), by Lilienfeld (*Arch. Physiol.*, 1892, 115; *Verh. d. Physiol. Ges.*, Berlin, 1891-2, No. 16), and by Halliburton and Brodie (*Brit. Med. Jour.*, March, 18 and 25, 1893, also *ibid.*, 1893, ii. 133). In all of these the influence of the work of Wooldridge and Pekelharing is seen. All agree in the importance now attributed to nucleo-albumin, and the idea of a ferment is becoming subsidiary. The blood-platelets, which Lilienfeld shows to consist of nucleo-albumin, seem to be very generally regarded as disintegration products of the colourless corpuscles. Wright specially insists on the important part played by carbonic anhydride in the coagulation process.

The blood corpuscles have been studied by Bleibtreu (Pflüger's *Archiv*, li. 151; lii. 323), and by Lange (*ibid.*, lii. 427). These investigators devised an ingenious method of estimating the volume of the corpuscles by estimating the nitrogen by Kjeldahl's method in mixtures of blood and salt solution, and in the serum of the same blood. Their results, however, are invalidated by the erroneous assumption that the salt solutions employed have no solvent or osmotic action on the corpuscles. This is fully pointed out by Hamburger (*Centr. Physiol.*, June 17, 1893, and Jan. 24, 1894), who has also extended his observations on the osmotic phenomena of blood corpuscles in relation to acids and alkalies (Du Bois Reymond's *Archiv*, 1892, 513; *Rec. Trav. Chem.*, ii. 61).

The dissociation of oxyhæmoglobin in aqueous solutions has been afresh investigated by Hüfner (*Zeit. physikal. Chem.*, ii. 794); and a number of respiratory pigments in invertebrates, which play the same *rôle* as hæmoglobin in those animals, have been the subject of numerous papers by A. B. Griffiths ("On Echinochrome," *Compt. Rend.*, cxv. 419; "On Hæmerythrin," *ibid.*, cxv. 669; "A Colourless Respiratory Globulin in Molluscs Blood," *ibid.*, cxv. 474, 1206).

Perhaps, however, the most interesting paper on

hæmoglobin that has recently appeared is that by Y. Inoko (*Zeit. physiol. Chem.*, xviii. 57), and the following is a brief *résumé* of it. Hoppe-Seyler, and later Jaquet, showed that the blood crystals from birds contain phosphorus; this has been explained by the presence of a nucleus in their blood corpuscles. The present investigation relates to (1) whether nucleic acid can be obtained from birds' blood crystals, and (2) whether an analogous crystalline compound can be obtained by adding nucleic acid to the oxyhæmoglobin of mammals' blood. The answer to the first question is in the affirmative, as adenine was obtained from the crystals. With regard to the second point, oxyhæmoglobin was prepared from horses' blood, and dissolved in a solution of nucleic acid, and cooled to 0° C., when a substance crystallised out in prisms, which contained 0·4 per cent. of phosphorus; that is approximately the same as in the blood crystals of the goose.

The blood pigment leads one next to speak of the use of iron in the form of anæmia called chlorosis. A number of papers on the absorption of iron have already been alluded to under the head of nutrition. In addition to these, three more must be mentioned; the first by E. L. Jones (*Brit. Med. Jour.*, 1893, ii. 670), whose observations are chiefly on the specific gravity of the blood in this condition; the second by C. T. Mörner (*Zeit. physiol. Chem.*, xviii. 13); on the whole Mörner supports Bunge's views of the *modus operandi* of iron as a drug; he, however, finds that iron salts are not general antiseptics, but their usefulness depends on the readiness with which they form the sulphide and so remove hydrogen sulphide from the alimentary canal. The third paper is by R. Stockman (*Brit. Med. Jour.*, 1893, i. 881), and contains the strongest evidence yet adduced against Bunge's view and in favour of that which teaches that the iron given as a drug is itself assimilated. The main grounds on which this conclusion is based are the following: (1) Iron inorganic compounds cure chlorosis when given hypodermically; (2) sulphide of iron itself

cures chlorosis; (3) bismuth, manganese and other drugs which are just as capable as iron of combining with hydrogen sulphide, do not cure chlorosis.

In reference to animal pigments, other than those contained in blood, the only paper worth mentioning is that by Prof. Church (*Proc. Roy. Soc.*, li. 399) on the peculiar copper-containing pigment found in the feathers of certain birds, and to which he has given the name turacin.

*Urine.*—A good many references have already been made to papers in which a consideration of the urine forms part. Those which have not been already mentioned are the following:—

"The Work of the Kidney," by W. H. Thompson (*Brit. Med. Jour.*, 1893, ii. 681); the experiments made on dogs, in which the urine was collected after the intravenous administration of atropine and morphine, showed a diminution of secretion which could not be explained by interference with blood pressure; this, taken with the fact that heat is produced in the kidney during its work, tends to the belief that some of the urea is formed in the kidney itself, and that this process of true secretion is lessened by drugs which produce similar effects in other glands.

"Fœtal Urine," by L. A. Helme (*ibid.*, 1893, 1261); a small quantity accidentally obtained during delivery was found to contain urea (0·15 per cent.), creatinine and chlorides, but no phosphates, sulphates, sugar, or albumin. Eight hours after birth, sugar, albumin, and phosphates were absent, but sulphates, chlorides, creatinine (in larger amounts), and urea (0·3 per cent.) were present.

With regard to individual constituents of the urine the following papers may be noted: "A quantitative study of the phosphates of a horse's urine," by L. Liebermann (Pflüger's *Archiv*, l. 57); "On urobilin," by F. Grimm (Virchow's *Archiv*, cxxxii. 246), who finds this pigment absent in fasting urine; and by A. Eichholz (*Jour. Physiol.*, xiv. 326), who regards hydrobilirubin as an intermediate

stage between bilirubin and urobilin; on hæmatoporphyrin, by A. E. Garrod (*Jour. Physiol.*, xv. 108), who considers this substance to be a constituent of normal urine which is much increased in a variety of pathological conditions; and by L. Zoja (*Cent. Med. Wiss.*, 1892, 705), who compares together the properties spectroscopic and otherwise of hæmatoporphyrin and uroerythrin. He regards MacMunn's urohæmatoporphyrin as a mixture of hæmatoporphyrin with urobilin. On uric acid, by G. Salomon (Virchow's *Archiv*, cxxxii. 170). In relation to Horbaczewski's work, the author advances a claim for priority. C. Wulff (*Zeit. physiol. Chem.*, xvii. 634) criticises Horbaczewski's work on the formation of uric acid from nuclein, which, however, that observer has since defended (see paragraph on Proteids). On Phenol in urine a paper by Kossler and Penny (*ibid.*, xvii. 117) gives an excellent account of the methods of estimating this substance volumetrically.

A number of papers on sugar in urine will be found referred to in the paragraph on Carbohydrates. In addition to these the student of diabetes should consult the following: the Relation of the Urinary Carbohydrates to Humous Substance, E. Salkowski (*ibid.*, xvii. 229); on $\beta$-hydroxybutyric acid in the organism by T. Araki (*ibid.*, xviii. 1); here support is lent to Minkowski's theory that acetone and aceto-acetic acid originate from this substance. There are also a number of papers on artificial diabetes, namely, on Pancreatic diabetes (V. Harley, *Brit. Med. Jour.*, 1892, ii. 451); and on Phloridzin diabetes by Cremer and Ritter (*Zeit. Biol.*, xxvii. 459, xxix. 256), by W. Prausnitz (*ibid.*, xxix. 168), and by M. Cremer (*ibid.*, xxix. 157). These work out various points of detail in connection with this subject but do not add anything striking to our knowledge of the diabetic condition.

One other abnormal condition of the urine remains to be mentioned, and here H. Embden (*Zeit. physiol. Chem.*, xvii. 182) fully confirms Baumann and Wolkow's con

clusions that alcapton is identical with homogentisic acid, and that it takes origin in the body from tyrosine by an abnormal metabolic process.

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